BANGALORE DEVELOPMENT AUTHORITY

Design, Construction & Commissioning of 75 MLD (25 MLD and 50 MLD) Capacity Sewage Treatment Plant (STP) using Sequential Batch Reactor (SBR) Process Technology with Biological Nutrient, Nitrogen & Phosphorous Removal System including 6 Nos., of RCC Wet Well Cum Pump house and 8 Nos of Machine hole Pumping Stations with All Electro-Mechanical Instrumentation, SCADA and allied Civil Works for Dr. K.Shivarama Karantha Layout, Bengaluru

including Five Years of O & M during operation Period

EMPLOYER'S REQUIREMENT

Office of the Executive Engineer, Dr.K.Shivarama Karantha Layout,Division-I
BANGALORE DEVELOPMENT AUTHORITY
Kumara Park West, T.Chowdaiah Road, Bengaluru-560020
Bangalore -560009.

VOLUME 2

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VOLUME 2

Section 7: Specifications

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PART 1

PROJECT REQUIREMENTS

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PART 1

PROJECT REQUIREMENTS

1.1 Background to the Project

Bangalore Development Authority has proposed the formation of Dr. K. Shivarama Karantha Layout on a land measuring of about 14351379.62 Sq. m (3546 Acres 12 Guntas). Out of which, sanctioned private layout plan / development plan is 108 Acres 28.5 Guntas, Sanctioned building plan is 04 Acres 07 Guntas, built-up in the notified area (clustered / scattered development) is 492 Acres, 8.5 Guntas, and the Lakes area notified by the authority is 08 Acres 34 Guntas), hence total extent of the land available for layout formation is 2935 Acres 14 Guntas out of 3546 Acres 12 Guntas

1.2 Project Brief:

The Total Project area have been divided into 9 sectors, to facilitate to provide all the necessary infrastructure & Utility service to the communities and commercial establishments. In the proposed Sewerage (UGD) system, it has been envisaged to propose the Sewerage collection System, Pumping main. Intermediate Pumping station (IPS) Transmission main and 2 numbers STP. The proposed two numbers STPs with a capacity of 25 MLD for Ultimate design year (2051) at Sector 01 and 50 MLD at Sector 08 respectively. As per the design 6 Numbers of Intermediate pumping stations (SPS) have been proposed to facilitate to pump the sewerage to 2 Nos STP. The treated Sewerage water shall be discharged to the water bodies and intial stages about 30% of the Treated Sewerage Water shall be utilized for road side gardens, parks and Community Amenities and for the purpose two number OHT to store the Sewrrage Treated water and saparete reclaimed distribution water pipe line hae been proposed

1.3 Proposed Sewage Treatment Plant

BDA has decided to set up a new 75 MLD STP (25 mld at Sector 1 and 50 mld at sector 8), Dr. K. Shivarama Karantha Layout situated East of Bengaluru. It is proposed Waste Water Treatment Process with primary treatment in the form of screening and de -gritting, oil & grease removal, secondary treatment in the form of Sequencing Batch Reactor Process (SBR) and tertiary treatment consisit of on line disc filters, glass media filtration, activated carbon adsorption and final disinfection and ozonation to achive standards of discharge as per NGT norms with specific refrance to COB, Phosphorus and TSS.

1.4 Description of the Works

1.4.1 Description of the Works

1) The Sewage Treatment Plant at Dr Shivarama Karatha Layout shall comprise the following components:
   (a) Components and unit processes as described in Volume 2, Section 7, Part 5 (Process Requirements) of these tender documents
   (b) All functional buildings, structures, equipment, and any and all other items, accessories, and ancillaries required for proper functioning and operation of the above components and unit processes.
   (c) Civil and Building Works for
      - Structures for afore mentioned processes
      - Pipeline Systems and Channels
      - Roadways, Curbs, Pavements, Parking Spaces, and associated drainage
      - Pumping Mains
   (d) Complete Electrical Equipment and Systems
   (e) Complete Mechanical Equipment and Systems
   (f) Complete Instrumentation, Control, and Automation Equipment and Systems
   (g) Civil, Mechanical, Electrical, and Instrumentation, Control, and Automation Erection Installation, Testing, and Commissioning Services

1.5 Scope of Work

The Scope of Work under this contract includes but is not limited to the following in relation to the design, construction, and operation of the Works:

- Site Topographic Survey and Geotechnical Investigations as deemed necessary by the Contractor
- Setting out of the works
- Site Clearing, Excavation, Leveling, Grading and Backfilling Activities
- Process, Hydraulic Design and Mass Balance
- Preparation of GA Drawings, Site Layout, Unit Process/Equipment/Facility/Building layouts, Hydraulic Profile, Process Flow Diagram, Process and Instrumentation Diagram (P&ID)
- Detailed Sizing, Design, and Engineering, of all treatment units, buildings, structures, and equipment (including all civil, mechanical, electrical, architectural, instrumentation, control, automation, and SCADA components)
- Design and Construction of all Civil Structures and Building Works
- Design, Construction and Commissioning of Bypass Lines
- Submission of Detailed Engineering Designs, Drawings, Process Calculations, Data Sheets as per bid requirements
- Procurement, Supply and Installation, Erection of all Mechanical, Electrical, Instrumentation, SCADA Equipment
- Execution of all Civil, Mechanical, Electrical, Instrumentation, SCADA Works at Site including Construction, Erection, Testing, commission and operation and maintenance for 5 years
- Construction of Internal Plant Roads, Curbs, Pavements, Parking Spaces, Compound Wall, Plant Water Supply and Sewage Disposal and Storm Water Drains
- Site grading, engineering embankment, compaction, erosion and sedimentation control, slope stability, protection measures, including foundation requirements, revetment / pitching, aprons, including retaining wall required as per site conditions, inclusive of areas over swamps for the required plant layout area in consideration of all the stability requirements and the site area for the required finished ground level including all considerations but not limited to the above- with necessary erosion control and protection measures for the plant layout as per site conditions.
- Plant water system and bore well water system including Yield study for Bore wells shall be carried out and for submitted to Employer's review and approval.
- Transportation and disposal of sludge
- Plantation and Landscaping work: Area for landscaping will equal to total area of project site minus area for the treatment plant units minus the area required for roads, sidewalks and drains.
- Receiving Raw Inlet Sewage at site and discharge of Plant Effluent to nearby nala/treatment facility as specified in Employer's requirements
- Design, construction, and commissioning of pipelines, conduits for the disposal of plant effluent from clarified effluent storage tank to nearby water body.
- Plant Testing, Commissioning, Stabilization, Demonstration of Performance Guarantee. This item shall include proper maintenance according to manufacturers' instructions of entire plant and its components during any inactive period that may be required if influent wastewater is not available at the time of STP completion.
- Submission of Operation and Maintenance Manuals
- ***Five years (05) Years Operation and Maintenance with one (1) year of defect laibality (DLP) period*** of constructed facilities from the date of completion of the Works and successful passing test on completion as per the Conditions of Contract given in Volume-1 of tender document.
- Providing Training Services to Employer's Personnel
- Preparation and Submission of As-Built drawings for all Civil, Mechanical, Electrical, Instrumentation, SCADA Works

- Design, construction, installation, testing, commissioning, and training for any and all other equipment, systems, components, and/or services that might be necessary for a complete, fully functional facility in compliance with all requirements of these tender documents.
- Contractor get all the Hydrilic design, Strctural design, SCADA and drawings approval by the IISc, Bangalore for each STP and pumping station for the project

1.6 Funding Agency

Funds for Contract are being provided by Bangalor Development Authority

1.7 Site Conditions at Plant Locations

The site conditions prevailing at the location to be considered for design are as given below;

Ambient temperature (plant room)	- 35^{o}C
Design temperature for electrical works	- 40 ^{o}C
Annual average temperature	- 32 ^{o}C
Relative humidity	- 80% at max. temperature
Site conditions	- Tropical
Ground elevation	- As per Topo Survey
Nala HFL	- As per site

1.8 Design Life (Minimum)

The Plant components shall be designed and constructed to provide the minimum service life listed below for each component.

Buried Piping	:	75 years
Reinforced Concrete Structures	:	60 years
Other Concrete Structures	:	50 years
Steel Structures	:	50 years
Mechanical Equipment	:	20 years
Electrical Equipment	:	15 years
Buried Earth Electrode System	:	40 years
Control Panels	:	15 years
Instrumentation Systems	:	15 years
Computer Systems	:	10 years

1.9 Survey and Geotechnical Data

Tenderer carry out the topographical survey, geotechnical investigation and all other details necessary for proper formulation of his price proposal before submission of tender.

After award of contract, Contractor shall carry out independently fresh survey, geotechnical investigation and all other details necessary for proper planning and detailed design. The Contractor will be required to provide full details of the survey and geotechnical investigations for each location for approval of the Employer.

1.10 Access for Other Contractors

The Contractor shall allow reasonable access to other Contractors engaged on the Site or on areas adjoining the Site to carry out their works.

In the event of a dispute over access or priority between Contractors, the Engineer shall be informed in writing. The Engineer shall inform all parties concerned in writing of his decision.

Where any part of the Works is associated with or in physical contact with plant supplied under a separate contract, the Contractor shall satisfy himself that the work carried out by the other contractor is consistent with the correct operation of the Plant. In the event of the Contractor considering any work being carried out or any work already completed to be detrimental to the ultimate operation of the Plant, he shall report the matter at once to the Engineer.

If the work of the Contractor is delayed because of any acts or omissions of any other Contractor, the Contractor shall have no claim against the Employer on that account other than for an extension of time.

1.11 Interface with Other Contracts

The Works under this Contract will physically interface with Works under the respective other contracts. The Contractor of this contract shall co-ordinate with Employer and the Contractor of other contracts as applicable and ensure that all interfaces are designed, constructed, installed, tested, commissioned, operated, and maintained properly to provide a fully functional system meeting all applicable performance requirements.

Available interface information for STP is provided in Volume 2, Section 7, Part 5. However, neither the Employer nor the Engineer make any representation regarding the validity, accuracy, adequacy, or completeness of this information. The Contractor of this contract shall be fully responsible for independently field-verifying any and all information he considers relevant in order to provide a fully functional system.

End of Part 1

PART 2

THE SITE

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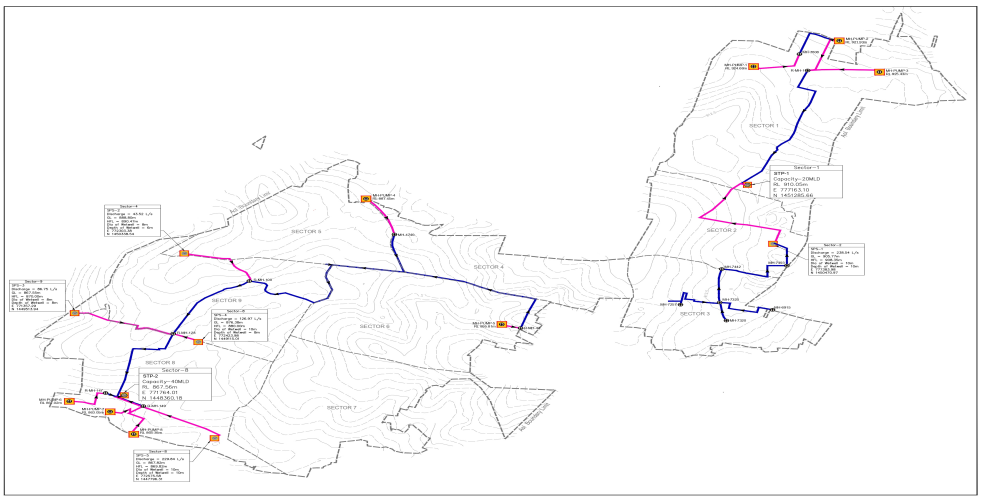
PART 2 - THE SITE

2.1 Location of the Sites

The Total Project area have been divided into 9 sectors, to facilitate to provide all the necessary infrastructure & Utility service to the communities and commercial establishments. In the proposed Sewerage (UGD) system, it has been envisaged to propose the Sewerage collection System, Pumping main. Intermediate Pumping station (IPS) Transmission main and 2 numbers STP. The proposed two numbers STPs with a capacity of 25 MLD and 50 MLD at Sector 01 at Sector 08 respectively. As per the design 6 Numbers of Intermediate pumping stations (SPS) have been proposed to facilitate to pump the sewerage to 2 Nos STP. The treated Sewerage water shall be discharged to the water bodies and also about 30% of the Treated Sewerage Water shall be utilized for road side gardens, parks and Community Amenities

The location of the proposed STP site is appended below;



Key Map Showing Location of Proposed STP Site at Bangalore Development Authority

2.2 Access to the Sites

The Employer will afford to the Contractor access to and possession of the Site for carrying out the Works. The Contractor shall be deemed to have inspected the STP Site including access before submitting his Bid.

The Contractor shall ensure that all the plant components offered are of a size and weight or can be divided into sections of a size and weight suitable for access to the place of installation.

The Contractor shall ensure that equipment used for installation purposes shall be able to gain access and position for such purposes.

2.3 Maintenance of the Site

The Contractor shall be responsible for maintaining all the site structures, buildings, equipment, contract display board and related services until expiration of the Contract period or until such time as the aforementioned facilities are removed with the Engineer's prior approval, whichever is earlier.

At proposed STP site under the contract, access main gate and access road extension shall be provided by the Contractor. The site boundary wall min 2.5 m height above GL made out of hallow bricks with one row ofGalvanized Iron Boundary Circle Razor Wire on top around the boundary of the proposed STP shall be provided by the Contractor.

2.4 Areas outside the Site

In the event of the Contractor making use of any special or temporary way leave or accommodation acquired by him or any tip for the disposal of surplus materials, or any borrow pit or quarry, he shall obtain the written consent of the owner, occupier or authority having charge of the land in which such way leave, accommodation, or tip is situated and shall make a written record, acknowledged and signed by the owner, of the condition of the surface of that land before entering thereon, with liberal use of photographs.

The Contractor shall permit the Employer and the Engineer and any person authorised by the Employer access for the purposes of the Contract to any such special or temporary way leave or additional accommodation.

In the event of the Contractor making use of any special or temporary way leave or additional accommodation made available to him by the Employer for the purpose of the Contract, the land in which such way leave or accommodation is situated shall be deemed to be part of the Site. Under these circumstances the Contractor shall form a Working Area extending no more than 5 m from the edge of the Permanent Works or accommodation on all sides. The Contractor shall restrict his activities to within this Working Area. On completion of the works in this area, the Contractor shall reinstate the area to its original condition to the satisfaction of the Engineer. For the purposes of this Clause, “accommodation” shall be deemed to include housing, offices, workshops, warehouses, and storage areas.

2.5 Road Works

The Contractor shall obtain all permits required for carrying out works such as excavation on public roads and shall liaise with the appropriate authorities with regard to the timing and execution of the road works.

The Contractor shall be responsible for establishing and maintaining temporary road diversions for the duration of the road works. The road shall be kept open at all times during the road works period, and the work shall be carried out in such a manner as to minimise the disruption to traffic. The Contractor shall reinstate all the roads to their original condition to the satisfaction of the Engineer after completion of works.

2.6 Maintenance of Existing Access Roads

The Contractor shall only use existing access roads within the Site boundary which are necessary for the execution of the Works. The Contractor shall obtain the Engineer's approval in writing before utilising existing access roads within the Site. Once the Engineer's approval has been given the Contractor shall be solely responsible for the maintenance of the existing site access roads. This responsibility shall continue until the completion of the Defects Liability Period, or until such earlier date as the Engineer may advise the Contractor in writing. Such maintenance work shall include general up-keep and any necessary repairs to damaged road surfaces, pavement, drainage, associated slopes, etc. to a standard at least equal to their original condition. While carrying out such maintenance work, the Contractor shall make arrangements to maintain through passage for the Employer's and his staff's vehicles and also those of other contractors over these access roads. Such arrangements may comprise temporary diversions, all to the approval and satisfaction of the Engineer.

The Contractor shall not run tracked or unsprung vehicles on surfaced roads without the written approval of the Engineer who may require that planking or some other protective material be used to protect the road surface.

2.7 Clearance of the Site

The Contractor shall clear the Site to the extent required by the Engineer for checking the setting-out.

Clearance of the Site shall also include demolition and removal of all articles, objects and obstructions which are expressly required to be cleared.

The Contractor shall ensure that the parts of the Site to be occupied by the Permanent Works are clear, and shall maintain the remainder of the Site as may be required for access and temporary works areas.

The Contractor shall remove the material arising from such clearance and dispose of it in a manner and at a location that are both in compliance with all applicable laws and regulations.

The Contractor shall backfill with appropriate specified materials and procedures those cavities and losses of soil which result from clearing the parts of the Site not subsequently to be occupied by the Works.

The Contractor shall not clear the Site of any existing structure(s) without the prior written instruction of the Engineer.

2.8 Clearance and Reinstatement of the Site on Completion of the Works

On completion of the Works, the Contractor shall clear any temporary works areas and temporary access roads and reinstate the areas to their original condition and to the satisfaction of the Engineer.

2.9 Access for the Employer and Engineer

The Contractor shall permit the Employer and the Engineer and any person authorised by the Employer or the Engineer including workmen of the Employer, other Contractors or utility undertakings access for the purposes of the Contract to all areas of the Site and to any additional accommodation or temporary way leave for the duration of the Contract period.

2.10 Water Supply at Site

The Contractor shall make his own arrangements for water supply at the site for the duration of the contract.

The Contractor shall ensure the quality of the water remains suitable for the purpose for which it is intended. The Contractor shall also conduct weekly test for water quality and comply with the quality requirements.

Wastewater shall be disposed off clear of the Site to the satisfaction of the Engineer so as to maintain the hygienic condition at the site and no damage or complaint.

2.11 Toilets, Latrines, Washing Facilities, and Wastewater Disposal

Throughout the period of construction of the Works the Contractor shall provide, maintain, and cleanse suitable and sufficient toilets, latrines and washing facilities for use by his employees. He shall ensure that his employees do not foul the Site but make proper use of the latrines.

Where practicable all wastewater generating facilities on site shall be connected to the nearest public sewer or if this is not practicable the Contractor shall provide an adequately sized septic tank and soak pit.

After completion of the works, the temporary toilets, latrines, washing facilities, septic tanks, and soak pits shall be removed, all ground disinfected and the surface restored to its original condition to the satisfaction of the Engineer.

2.12 Electricity for Contractor's Use on Site

The Contractor shall be responsible for provision of an electric supply to the site, energy meter, and distribution of the supply for the purpose of constructing the Works.

The installation shall comply with all the relevant regulations, Indian Standards and Codes of Practice, and Health and Safety requirements. The Contractor shall take all precautions to ensure that the installation is safe and injury to personnel or damage to plant and buildings is avoided. The Contractor shall be fully responsible for all safety aspects.

The Contractor shall test the temporary site power distribution system including energy meter every 3 months for compliance with the relevant standards.

2.13 Camp Facilities

The Contractor shall construct and maintain to the Engineer's satisfaction a camp to provide living accommodation for all Contractors staff and operatives who have no other local accommodation. The Contractor's camp shall be located close to but not on the Site itself and at a location approved by the Engineer.

Responsibility for providing all services to the living quarters and compliance with all sanitary laws and other laws and regulations shall be borne by the Contractor. Security and the fencing of these areas shall be the responsibility of the Contractor.

2.14 Compressed Air Use on Site

The Contractor shall provide the necessary compressed air plant and equipment required for construction of the Works.

Electrically driven compressors connected to the site electricity supply shall not be used. Diesel engine driven compressors shall not be sited within buildings or in a location that may cause a health hazard to personnel owing to exhaust fumes or noise.

2.15 Refuse Disposal on Site

Refuse and rubbish of every kind shall be removed from the Site and disposed of by the Contractor at his own expense, frequently and regularly at a minimum period of one week so as to keep the Site in a wholesome and tidy condition to the satisfaction of the Engineer.

2.16 Safety and Security on Site

The Contractor shall at all times maintain safe work methods and procedures and shall comply with all enactments, regulations and working rules relating to safety, security, health and welfare of all persons who may be affected by his work.

In particular he shall ensure that only persons who are properly trained for their duties are employed, and that appropriate, approved tools, safety equipment, and procedures are used.

Nothing which has been written into or omitted from the Employer's Requirements shall be taken to relieve the Contractor from his obligations under this clause. No clause in the Employer's Requirements shall prevent the Contractor from drawing the attention of the Engineer to any feature of the Works which is not consistent with normal safety practices nor prevent him from putting forward proposals at any time which would increase the safety of the installations.

Not later than four weeks before work commences on the Site, the Contractor shall submit to the Engineer his comprehensive plans and proposals relating to the all aspects of health and safety on the Site. The proposals shall be appropriate for all grades of labour and personnel who will work on or visit the Site on behalf of the Employer, Engineer or Contractor.

The Contractor shall appoint a suitably qualified representative as Safety Officer who shall be responsible for the implementation of site procedures as per relevant standards. The Safety Officer's responsibilities shall include but not be limited to:

- Safety;
- working in hazardous areas;
- permit to work;
- fire and smoking regulations;
- first aid;
- warning signs;
- trenching scaffolding and other construction structures;
- safety barriers;
- protective clothing and equipment;
- safety training;
- safety meetings and inspections;
- health and welfare.

The Engineer shall have the power to stop any activity or work in any area where there is a breach of the published site safety rules or health and safety is otherwise endangered.

The Contractor shall ensure that all other Contractors working on the Site also follow established health and safety procedures. The Contractor shall bring any violation of Site safety rules by others to the attention of the Engineer in writing.

2.17 First Aid and Life-saving Apparatus on Site

The Contractor shall provide on the Site such life-saving apparatus as may be appropriate and an adequate and easily accessible first aid outfit or such outfits as may be required in any government ordinances, factories acts, etc, published and subsequently amended from time to time. In addition, an adequate number of persons permanently on the Site shall be instructed in their use, and the persons so designated shall be made known to all employees by the posting of their names and designations in a prominent position on Site.

2.18 Electrical Safety on Site

The Contractor shall be responsible for the electrical safety of all Plant and equipment supplied and installed. Whilst any equipment is being installed or tested, the Contractor shall ensure that all necessary precautions are taken to safeguard personnel working on site. If necessary, this shall include fencing off areas which are considered to pose a risk, and erecting warning notices.

The Contractor shall be responsible for ensuring that the electrical installation is carried out by suitably trained competent personnel and that the work is carried out in a safe manner.

The Contractor shall be responsible for the operation on the Site of a permit to work system during the period of electrical equipment installation and testing. This system shall regulate the installation, the energization and the use of electrical Plant and equipment installed and the method of work adopted.

2.19 Noise

The Contractor shall ensure that the operations entailed in the construction of the Works do not cause annoyance to others working on the Site or to persons living adjacent to the Site.

2.20 Warning and Safety Signs

During construction of the Works statutory safety signs shall be adequately provided throughout the Works, both indoors and outdoors. These safety signs shall cover mandatory, prohibition, warning, emergency, fire-fighting and general notices. All signs shall be positioned around the Works at highly

visible points. Provision of signs and the positions of signs shall be subject to the Engineers approval. Special attention shall be given to areas designated hazardous.

Warning signs shall be in English, Kannada and Hindi Languages.

2.21 Site Working Hours

The Site working hours are detailed in the Appendix to the Tender.

The Contractor shall not extend the working hours without the prior approval of the Engineer.

2.22 Delivery to Site

The Contractor shall be responsible for the transporting, handling, and delivery to site of all the Plant and equipment. The proper storage and protection of all Plant and equipment at the Site shall be the Contractor's responsibility.

The Contractor shall check all items against packing lists immediately on delivery to the Site and shall also inspect for damage and shortages. Damages and shortages shall be remedied with the minimum of delay.

The Contractor may, with the prior approval of the Engineer and at no extra cost to the Employer, make arrangements for any other contractor or agent to take delivery of, unload and store the Plant on the Site on behalf of the Contractor.

All deliveries shall take place during the Contractor's normal working hours.

2.23 Protection from Weather and Storage

An area and/or building on the Site for use by the Contractor for storage of Plant prior to erection will be subject to the approval of the Engineer.

The Contractor shall provide all facilities for the safe and proper storage of Plant and equipment, as recommended by the manufacturers, with particular consideration being given to temperature, rain, sunlight, wind and ground conditions.

The Contractor shall remain responsible to the Employer for the care and insurance of the Plant and the provisions of this Clause shall not relieve the Contractor of any of his liabilities under the Contract.

Stored Plant items shall be laid out by the Contractor to facilitate their retrieval for use in the required order as recommended by the manufacturer.

Stacked Plant items shall be protected from damage by spacers on load distributing supports and shall be safely arranged. No metalwork shall be stored directly on the ground.

Small Plant items shall be held in suitable bins, boxes or racks and be clearly labelled.

Items of Plant shall be handled and stored so that they are not subjected to excessive stresses and so that protective coatings are not damaged.

The Contractor shall comply with the manufacturer's package and plant markings concerning the use and location of lifting slings, chains and hooks, and all other handling, storage, protection, and installation instructions.

2.24 Datum Benchmark

All vertical elevations shown on the drawings included in these tender documents are based on a benchmark as shown on contour drawing enclosed in Volume – 3 for Dr Shivarama Karatha Layout

2.25 Contract Signboards

The Contractor shall supply and erect signboards at locations to be specified by the Engineer. The layout and dimensions of the signboards and their construction shall be to the approval of the Engineer and the lettering in Kannada, Hindi and English Languages shall be black on a white background.

2.26 Advertising

The Contractor shall not use any part of the Site for any form of advertising without the prior written approval of the Engineer.

End of Part 2

PART 3

GENERAL REQUIREMENTS

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PART 3

GENERAL REQUIREMENTS

3.1 Introduction

This Part sets out the technical requirements that are general to the Contract.

3.2 Technical Standards and Regulations

Except where otherwise specified in the bid document plant, materials and workmanship shall comply with the requirements of the relevant Indian Standards (hereinafter referred to as IS) issued by the Bureau of Indian Standards (BIS). Other equivalent National or International Standard Specifications such as those issued by the International Organization for Standardisation (ISO) or the International Electro technical Commission (IEC) may be substituted by the Contractor (so as long as they are more stringent than the equivalent IS) at the sole discretion of the Engineer or as may have been agreed in the Contract. All standards used shall be the current and latest version.

All works shall comply with all relevant statutory regulations and standards current at date of bids, unless otherwise indicated within the Employer's Requirements. Electrical installations shall, where relevant, be in accordance with the Indian Standards Code of Practice for Electrical Wiring Installations IS 732.

All materials, plant and equipment shall be new and all materials and workmanship not fully specified herein or covered by an approved standard shall be of such kind as is used in first class work and suitable to the climate in the project area.

Where reference is made in the Specification to a British Standard Specification (hereinafter abbreviated to `B.S.') issued by the British Standards Institution of 2, Park street, London W.I., or to an Indian Standard Specification (I.S.) issued by the Bureau of Indian Standards, (earlier known as Indian Standards Institution), Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002, or American Society for Testing and Materials (ASTM) issued by ASTM 1916 Race Street, Philadelphia, P.A., 19103, U.S.A. or American National Standards Institute (ANSI) issued by ANSI 1430, Broadway, New York, N.Y., 10018, U.S.A. or Japanese Industrial Standards (JIS) issued by Japanese Standards Association, 4-1-24, Akasaka, Minato-Ku, Tokyo 107, Japan or to any other equivalent Standard it shall be to the latest revision of that Standard at the Tender opening date.

The Contractor may propose, subject to employer approval and at no extra cost to the Employer, the use of any relevant authoritative internationally recognised Reference Standards, including Indian Standard (IS) and Japanese Industrial Standards (JIS), so long as they are at least as stringent as the equivalent IS if any.

All details, materials and equipment supplied and workmanship performed shall comply with these Standards. If the Bidder offers equipment to other Standards, the equipment/material should be equal or superior to those specified and shall be subject to approval by the Engineer and full details of the difference shall be supplied by the Contractor.

In the event of conflict between this Specification and the Codes for equipment, the most stringent provision shall govern, except as otherwise approved by the Employer. Certain specifications issued by national or other widely recognised bodies are referred to in this Specification. Such specifications shall be defined and referred to hereinafter as Standard Specifications. In referring to the Standard Specifications the following abbreviations are used:

IS	:	Indian Standard
ANSI	:	American National Standards Institute
API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society of Testing and Materials
AWS	:	American Welding Society
AWWA	:	American Water Works Association
ISO	:	International Organization for Standardisation
JIS	:	Japanese Industrial Standard
DIN	:	Deutsches Institute fur Normung
BS	:	British Standard
JWWA	:	Japanese Water Works Association
IEC	:	International Electro technical Commission
IEE	:	Institution of Electrical Engineers
IEEE	:	Institute of Electrical and Electronic Engineers
NEMA	:	National Electrical Manufacturers Association
AGMA	:	American Gear Manufacturer's Association

3.3 Precedence of Employer's Requirements

The requirements specified in the Particular Requirements parts, shall be in addition to those specified in the General Requirements parts. In case of conflict between the parts, the requirements of the Particular Requirements parts shall take precedence.

3.4 Units of Measurement

All designs, drawings, specifications and manuals shall use SI units and all measurements, dimensions and performance data shall be quoted in those units.

3.5 Programme

In accordance to Sub Clause 8.3 of the Particular Conditions of Contract, the Contractor shall submit within in the stipulated time detailed contract programme for approval, which shall include details of all temporary and permanent works, construction procedures and methodologies.

In addition to the requirements set down in the Conditions of Contract the programme shall include the following details:

(a) Contractor's organisational family tree for the Contract including details of all site supervisors and their responsibilities;

(b) A statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled labour to be employed on the Works;

(c) A list and type details of major constructional plant (including vehicles) which the Contractor proposes to employ on the Works, including programmed dates for order and delivery;

(d) Details of the Contractor's methods of working for all operations;

(e) A statement giving the proposals for location or locations and sizes of offices, workshops and stores at the Site;

(f) A complete resource allocation showing the number of units and allotted times for each unit of constructional plant, materials and labour allocated to each part of the Works;

The programme shall be co-ordinated to take into account the requirements of climatic, groundwater and other conditions to provide for the completion of the Works in accordance with the Contract.

The programme shall be prepared using MS Project software and shall be submitted in both electronic softcopy and paper hardcopy form.

3.6 Contract Management

The Contractor shall be responsible for administration of the Contract from award of Contract through design, manufacture, manufacturer's works testing, and delivery of Plant to Site, installation, testing and performance testing to final take over. For this purpose he shall nominate a Contractor's Representative in accordance with Sub-clause 4.3 of the General Conditions of Contract who shall be fully responsible for and undertake this administration.

Specific responsibilities of the Contractor's Representative shall be:

(a) The sole representation on behalf of the Contractor in all discussion, correspondence and matters relating to the Works.
(b) The co-ordination and monitoring of Contract progress, which shall include the preparation of the Contract programme, monitoring of progress and submission of monthly progress reports. At the discretion of the Engineer, regular meetings shall be called at which the Contractor's Representative shall give a full account of the Contract progress and programme.
(c) The co-ordination and checking of designs, drawings and submissions. The Contractor's Representative shall be responsible for co-ordinating the design, technical information and data between sub-contractors. All calculations, drawings and information submitted to the Engineer shall be checked by the Contractor's Representative and certified as having been checked before submission.
(d) Contract communication between the Engineer and the Contractor. The Contractor's Representative shall attend all meetings involving the Contractor and the Engineer.
(e) The co-ordination and programming of manufacturer's works tests and the submission of test certificates.
(f) The co-ordination and programming of Plant delivery.
(g) The co-ordination and programming of the installation of Plant on the Site, site tests and take over trials. The Contractor's Representative, although not necessarily based at the Site, shall be responsible for the various sub-contractors. At the discretion of the Engineer regular site meetings will be held during which the Contractor's Representative shall give full account of site progress and programme.
(h) The Contractor's Representative shall also be responsible for producing in advance of the work being undertaken, detailed method statements of any work, which involves or affects the performance of existing equipment, processes, or disruption to existing water supplies.
(i) The co-ordination and preparation and submission of As-Built Drawings and Operation and Maintenance Manuals.
(j) Soft copies of all submissions should be in editable form.
(k) The preparation and co-ordination of training of Employer's Personnel.
(l) The submission of applications for payment.

3.7 Meetings

From time to time the Engineer will call meetings in the client office or at the Site, as he deems necessary, to discuss progress and any technical points requiring settlement.

The Contractor's Representative or responsible representative shall attend such meetings. The representatives from Contractor who's Curriculum vitae submitted and accepted by the Engineer vide Technical schedule – I during Technical bid evaluation or Equivalent engineers with the minimum qualification and experience mentioned in Technical schedule –I are only eligible to attend meetings.

The Contractor shall prepare and submit to the Engineer a daily activity report summarising the main activities undertaken each day.

3.8 Site Photographs

The Contractor shall supply Orginal / negatives of photographs and unmounted positive colour prints not less than 250mm x 200mm of such portions of the Works, in progress and completed, as may be directed by the Engineer and specified herein. Contractor shall submit digital photographs in electronic format on any standard digital media such as memory card or CD for every fortnightly. No prints / soft/ digital copies of these shall be supplied to any other person without the written permission of the Engineer.

The photographs shall be of following categories:

- progress photographs
- record photographs
- Video (CD)

All categories of photographs shall be properly referenced to the approval of the Engineer, and on the back of each print shall be recorded the date and time of the photograph, the direction in which the camera was facing, an identifying description of the subject and the reference.

Photographs taken for record purposes as ordered by the Engineer or as specified herein shall be supplied with soft copy and three prints, having the reverse of one superscribed with the signatures of the Contractor and the Engineer (or their authorised representatives) for the purpose of attestation. If required, the Contractor may at his own expense have an additional print similarly attested for his retention.

The Contractor shall supply one soft copy and three prints of each progress photograph ordered by the Engineer. The Contractor shall supply two additional prints of progress photographs selected by the Engineer for incorporation in albums. The Contractor shall supply two sets of albums, mount the prints, and title the prints and albums all to the approval of the Engineer.

The taking of photographs of the Works by the Contractor for any other purpose whether for use in India or in any other country shall not be carried out without written approval from the Engineer.

3.9 Setting Out of the Works

The Contractor shall set out the Works, and carry out the Contractor's quality control procedures verifying the accuracy and precision of the setting out for each item of the works. The Contractor shall notify the Engineer sufficiently in advance of the setting out to enable the Employers Representative to observe the accuracy and precision of the laying out. The observations of the Engineer shall not relieve the Contractor of the responsibility under the Contract for the accuracy and precision of the setting out.

3.10 Engineer's Requirements

The Contractor shall provide the following for use by Engineer at the each proposed plant sites covered under the contract. These items are to be maintained by the Contractor in proper, safe, and clean working condition throughout the construction period and shall be returned to the Employer after completion of works.

No separate payment shall be made for the items covered here.

3.10.1 STP

1. Lighting Distribution Board

1. 1 The Distribution Board shall be of high quality CRCA sheet steel enclosed, suitable for surface mounting on the wall. Premier quality powder coating shall be applied and the final shade shall be Light Grey Semi Glossy Shade 631 of IS 5.
1.2 The Distribution Board shall be provided with double door arrangement consisting of an intermediate plate with necessary windows and a door so that when the door is opened, live parts are not exposed.
1.3 The Distribution Board shall be provided with removable top and bottom gland plates with adequate number of knockouts to enable top and bottom entry of conduits and cables.
1.4 The Distribution Board shall be of phase segregated type.
1.5 The incomer shall be TPN, MCCB of required rating with ELCB or RCCB. The sub incomers for each phase shall be DP, MCB's of required rating. The outgoings shall be SP MCB's of required ratings.

2. Luminaries:

2.1 The luminaries for all office premises shall have the following features :

- The Housing made of epoxy powder coated extruded aluminium / CRCA sheet suitable for suspended /surface mounting/recess mounting
- Decorative low glare mirror optics with anodised aluminium louvers.
- Designed for 2x 36 W TL-D lamps with electronic ballast.
- Number of luminaries for each room shall be selected to achieve illumination level of 300 Lux.
- In addition to the above luminaries, down light with the following features shall be provided at the four corners of the conference room.

(i) Housing made of Powder Coated CRCA, Sheet steel, suitable for recess mounting with wide cast aluminium ring.
(ii) Anodised aluminium reflector for low glare and diffused lighting.
(iii) Suitable for horizontally mounted Single 18W CFL with electronic ballast.

2.2 The luminaries for other rooms & toilets shall have the following features :

- Housing made of Powder Coated CRCA Sheet steel, suitable for surface mounting on ceiling /wall.
- Cover made of Opal acrylic.
- Designed for 1x 36 W, TL'D' lamps with electronic ballast.

3. Ceiling Fans

The Ceiling Fan shall be of 48" size, 3 blades type. The fan shall be with aerodynamically balanced aluminium blades. The fan shall be provided with double ball bearings precisely aligned for noiseless performance. The fan shall be powder coated and complete with all mounting accessories. The fan shall be suitable for operation with electronic fan regulator. One Ceiling fan shall be provided for each 10 m^2 or part thereof of the area concerned.

4. Switchboards

The Switchboard shall have unbreakable concealed box and mounting plate flushed with wall. The mounting plate shall be of twin plate arrangement, inner plate to hold the modules and the outer cover plate. The switch board shall have required Nos. of switches for lighting fixtures & Ceiling fans. The switches shall be of modular type with minimum rating of 6 amperes. Each lighting fixture & Ceiling fan shall be provided with individual switch. The switchboard shall be provided

with one no 6 Amperes 5 pin universal socket with switch. Number of modules in the switchboard shall be to suit the actual requirement. At least 2 Nos., 6 A switches shall be provided in each switchboard as spares. The cover plate and switches shall be of white /cream in colour. Minimum One no Switchboard shall be provided in each of the premises.

5. Switch Sockets

The switch sockets shall have unbreakable concealed boxes and mounting plates flushed with the wall. The mounting plates shall be of twin plate arrangement, inner plate to hold the modules and the outer cover plate. Each switch socket shall be provided with 15 Amps, 240 V, Switch and 6 Pin socket. The number of switch sockets shall be 2 Nos. in each of the premises and one no in Pantry.

6. Power Plug & Sockets

The power sockets shall have unbreakable concealed boxes and mounting plates flushed with the wall. The mounting plates shall be of twin plate arrangement, inner plate to hold the modules and the outer cover plate. Each power socket shall beprovided with 16 Amps, 240 V, SPN MCB and 16 Amps, 240 V, 3 Pin socket and 16A 3 Pin Plug. The number of Power Plug & sockets shall be provided as per requirement in various premises & pantry.

7. Peripheral Lighting:

Bracket/Conduit mounted Peripheral Lighting shall be provided on all the corners of the building.

The Lighting fixture shall have the following features

- Weather Proof Housing made of Powder Coated CRCA Sheet steel.
- Cover made of Opal acrylic.
- Designed for 1x 36 W, TL'D' lamps with electronic ballast.

The Contractor shall arrange for a telephone line with STD facility at proposed STP site covered under the contract for sole use by Engineer. The Contractor shall pay for the installation charges. A separate provisional sum is allotted for the payment of calls made by the Engineer. The Contractor shall transfer the telephone instrument and its ownership to the Employer after completion of works.

The Contractor shall maintain ONE NEW/LATEST TYPE-MODEL SEDAN (A/C) vehicle for the contract to be kept available at all times for the sole use of the Engineer and his staff. The Contractor shall be solely responsible for the upkeep of the vehicle including taxes, insurance, licenses, fuel, oils, lubricants, repairs, and maintenance and shall also provide a competent driver along with the vehicle and driver shall be familiar with Kannada and Hindi Languages. At the end of works contract the Contractor shall transfer the vehicles in good condition to Employer.

3.10.2 Assistance to the Engineer

The Contractor shall provide all necessary assistance to the Engineer and his staff in carrying out their duties of checking, inspecting, and measuring the Works. The Contractor shall provide, at no additional cost, chainmen, staffmen, office attendants, and labourers as may be needed from time to time by the Engineer.

The Contractor shall provide for the Engineer and his staff, consultants and their staff and visitors such protective clothing, safety helmets and rubber boots of suitable sizes, hand lamps and the like as may be reasonably required by them. These articles shall remain the property of the Contractor. No extra payment shall be made on this account.

3.10.3 Instruments to be Provided

The Contractor shall provide at his own cost for the exclusive use of the staff of the Engineer all brand new survey equipment and measuring instruments of approved make and of every kind necessary for the execution of the Works, including

(a) One 360 degree circle optic theodolite, accurate to one second, complete with carrying case and sliding leg tripod.
(b) Two automatic surveyor's levels with horizontal 360 degrees circle, tripod with carrying case.
(c) Two staffs, 4.5 m long, each in 3 sections and with attached bubbles, graduated in metres and tenth and hundredths of a metre.
(d) Two Surveyor's steel bands of which one shall be 100 m long and approximately 20 mm wide and one shall be at least 30 m long and approximately 12 mm wide, each fully divided, complete with tape thermometers and tension handles and wound on an open plastic cross.
(e) An adequate number of ranging rods, steel and linen tapes, string lines, pegs, lines, spirit levels, survey umbrellas, lights, batteries, stores and tools.

The instruments mentioned above shall be for exclusive use of the Engineer and shall remain in the custody of the Engineer till the Works are completed.

The Contractor shall be solely responsible for all such instruments and equipment and shall ensure that they are at all times in good repair and adjustment, and shall make good any loss or damage howsoever caused. No extra payment shall be made on this account.

On completion of the Works, the entire set of instruments provided by the Contractor shall be the property of the Employer.

3.11 Erection of Plant

Erection of Plant shall be phased in such a manner as not to obstruct the work being done by other contractors.

Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of Plant are to be installed and shall bring any deviations from the required positions, lines or dimensions to the notice of the Engineer.

Plant shall be erected in a neat and workmanlike manner on the foundations and at the locations shown on the Approved Drawings. Unless otherwise directed by the Engineer, the Contractor shall adhere strictly to the aforesaid drawings.

The Contractor shall be responsible for setting up and erecting the Plant to the line and level required and shall ensure that all Plant is securely held and remains in correct alignment before, during and after grouting-in. This responsibility shall not be passed to any other contractor.

Any damage caused by the Contractor during the course of erection to new or existing plant or building or any part thereto, the Contractor shall at his own cost, make good, repair or replace the damage, promptly and effectively as approved by the Engineer and to the Engineer's satisfaction.

3.12 Site Labour and Supervision

The Contractor shall provide all the skilled and unskilled labour required, and all necessary tools and equipment, to erect, test and commission the Works within the period agreed in the programme.

The Contractor shall not remove any supervisory staff or skilled labour from the Site without the Engineer's prior approval.

3.13 Sub-letting

The Contractor shall not sub-let the whole of the Works. Where any design or manufacture is sub-let, the Contractor shall not be relieved of his obligation under the Contract. The Contractor shall be responsible for the acts, defaults and neglect acts in manufacture or design of any sub-contractor, as if they were his own.

Where the Engineer has consented to supply of Plant or execution of work by manufacturers or sub-contractors proposed by the Contractor, such manufacturers or sub-contractors shall not be changed without the prior approval in writing of the Engineer.

A copy of every sub-order shall be sent to the Engineer at the time the order is placed each clearly marked with the title of the Contract and the Contract number.

3.14 Temporary Works

Not less than 14 days before commencing any portion of the Works, the Contractor shall submit to the Engineer for his approval comprehensive drawings and calculations for all Temporary Works which the Contractor proposes for the construction of that part of the Works.

Notwithstanding approval by the Engineer of any design for the Temporary Works, the Contractor shall be entirely responsible for their safety, efficiency, security and maintenance and for all obligations and risks in regard to such Temporary Works specified or implied in the Contract.

3.15 Languages

All drawings, instructions, signs, notices, name-plates, etc. for use in the design, construction, operation and maintenance of the Works shall be in English.

All site sign boards and warning signs shall be in Kannada, Hindi and English Languages.

3.16 Drawings and Information to be provided

3.16.1 General

The drawings that will be prepared and issued for this Contract shall be classified as follows and where relevant shall be to a scale which is suitable for the representation of those details illustrated.

The term Drawing shall be deemed to include all drawings, schedules, lists, software documentation, descriptive text and calculations necessary for the design, construction, operation and maintenance of the Works and referred to in this clause.

Drawings and all other submittals required during bidding stage and after award of contract shall be submitted in editable electronic softcopy format on CD(s) or DVD(s) as well as in hardcopy paper format.

The softcopy format for various items shall be as follows:

- Drawings: AutoCAD version 2008
- Text Documents: Microsoft Word version 2003 or 2007
- All programmes and schedules related to the project: Microsoft Project version 2003 or 2007
- Spreadsheets, calculations, tables, technical schedules, prices schedules, and other numerical data: Microsoft Excel version 2003 or 2007
- Databases: Microsoft Access version 2003 or 2007
- All other required information not included in the above: Adobe Portable Document Format (PDF) version 7.x

The hardcopy format/sizes for various items shall be as follows:

- Drawings: Standard A1 size paper. The scale for each drawing shall be selected such that the information is presented without any clutter or ambiguity and is clearly and easily legible without the use of magnifying aids other than a reader's normal eye-glasses.
- All other information: Standard A4 or A3 paper size, except for any pre-printed standard information such as brochures or catalogue information, which may be submitted in the original size and format.

3.16.2 Drawing Format and Numbering

All drawings shall be prepared using an identical title block format. This shall be approved by the Engineer and shall identify the project, drawing title, the Employer, the Contractor, Sub-contractor, if applicable, and the Engineer.

A formalised drawing numbering system shall be adopted with digits of each number, referencing location, revision, drawing type and size. The numbering format and allocation of drawing number blocks shall be approved by the Engineer.

The Contractor shall provide a sequential numbering system for all Construction Documents. The drawing number shall not be repeated or duplicated.

All drawings shall be submitted to a formalised checking procedure prior to submission. Drawings not so checked will not be approved.

3.16.3 Pre-contract Drawings

The Pre-contract Drawings are those issued to Bidders either with the Bidding Documents for the purpose of illustrating and clarifying the Works described in the Employer's Requirements or later during the bidding period as part of an Addendum to the Contract Documents.

Such drawings shall be deemed to have been issued for the guidance of Bidders and shall, for the purpose of executing the Works, be superseded by the Construction Documents.

3.16.4 Bid Drawings and Details

The Bid Drawings are those furnished by a Bidder with his Bid for the purpose of illustrating and clarifying his proposals.

The following drawings, details and specific information pertaining to the entire sewage treatment process / plant shall be furnished by the Bidder for STP in the technical envelope in addition to other information mentioned elsewhere in the tender.

The lists provided below shall not be considered comprehensive. The bidder shall be responsible for including any and all drawings and information for any and all works that may be necessary for full and complete definition or clarification of the design, regardless of whether or not such drawings, information, or works are explicitly included in the lists below or elsewhere in these bid documents.

The bid drawings and other technical documents shall be submitted in soft copy format on CD(s) or DVD(s) well as in hardcopy paper format.

(a) General and Process

(i) Narrative Description of the Works
(ii) Plant Operation and Control Philosophy
(iii) Sizing and Design Calculations covering all Major Unit Processes and components of the Works
(iv) Complete Equipment List

(v) Plant Layout with List of all structures (basins, tanks, channels, buildings, etc.) including dimensions and freeboards
(vi) Hydraulic Profile
(vii) Process and Instrumentation Diagrams (P&IDs)
(viii) List of Chemical Consumption on Daily/ Monthly Basis

(b) Mechanical

(i) To-scale dimensional mechanical general arrangement drawings for the following Equipment, at a minimum:
- Raw Sewage Pump sets
- Submersible Mixers for Anaerobic and Anoxic zones and Fine bubble diffusers
- Chlorination system

(ii) Graphs for all major pumps and blowers (including but not limited to Raw Sewage Pumps, Primary Sludge Pumps, Return Activated Sludge Pumps, Mixed Liquor Recycle Pumps, Thickened Sludge Pumps, Biogas Scrubber Pumps, Centrifuge Feed Pumps, Process Air Blowers, Biogas Mixing Blowers, Biogas Scrubber Blowers, Scrubber Air Blowers, Hot water boilers):
- Pump Performance Curves : Q vs H, speed, P, Efficiency, and NPSH
- ISO-efficiency curves of the pump model proposed

(c) Electrical
(i) Electrical Single Line Diagram of STP.
(ii) Sizing Calculations for Transformers and DG Sets.
(iii) Electrical Load List & Power Consumption Chart with Specific Energy Consumption
(iv) Instrumentation SCADA

3.16.5 Details of Drawings and Calculations to be submitted by the Contractor for Approval

Drawings / Calculations for approval shall be submitted by the selected Contractor after award of the contract in two Phases.

Drawings and all other submittals required after award of contract shall be submitted in editable electronic softcopy format on CD(s) or DVD(s) . as well as in hardcopy paper format. The soft copy format shall be as per Clause 3.16.1

The first phase shall be the Preliminary Drawings / Designs. Drawings / Designs submitted during this phase shall be of sufficient detail for the Employer and Engineer to understand in outline the Contractor's proposals for the design and construction of the Works. The lists provided below shall not be considered comprehensive. The bidder shall be responsible for including any and all drawings and information for any and all works that may be necessary for full and complete definition orclarification of the design, regardless of whether or not such drawings, information, or works are explicitly included in the lists below or elsewhere in these bid documents.

The Preliminary Drawings / Designs for STP shall inter alia comprise priority A,B,C:

Priority A:

- Detailed Description of the proposed Sewage Treatment Plant and Treatment Process offered (including Raw and Treated Sewage Quality).
- Detailed Process Flow Diagram (inclusive of Mass Balance)
- Detailed Process Design Calculations and Mass Balance Calculations covering all Units/ Equipment.
- Plant water utility plan
- Vendor List for major mechanical and electrical equipment of STP and SPS

Priority B:

- Detailed Plant Layout (including Pipe Sizes/ Pipe Routing/ Channel Size/ Channel Routing/ Site Roads/ Site Drainage) with List of all structures (basins, tanks, channels, buildings, etc.) including dimensions and freeboards
- Full Hazardous Area Classification Analysis and Report per IS 5572 for STP in the contract.
- Hazardous Area Classification Drawings per IS 5572 for STP in the contract.
- Detailed Hydraulic Profile including Hydraulic Calculations;
- Detailed Chemical Consumption Calculations (Daily/ Monthly Basis).
- Preliminary Process and Instrumentation Diagram (P&ID)
- Preliminary Plant Operation and Control Philosophy
- Major Equipment /Instrument Specifications (with supporting Brochures).

Priority C

- Major Piping Schedule to include size, material, coating, lining, gauges/thickness, and pressure rating
- Major Valve Schedule to include size, type, material, pressure rating, operator/actuator type, and whether Open/Close or Modulating
- Gate Schedule to include size, type, differential head, seating or unseating, operator/actuator type, and whether Open/Close or Modulating

The second phase shall be the Detailed Engineering Design phase and shall comprise the submission of the Detailed Mechanical/ Electrical/ Instrumentation/ SCADA/ Structural/ Civil Construction Drawings and Calculations and Civil guideline drawings for STP and SPS. These shall be submitted after the approval of the Preliminary Drawings in the sequence namely, Mechanical General Arrangement drawings shall be submitted only after approval of Basic Engineering Package (BEP's) - Design drawing documents. Civil drawings shall be submitted only after obtaining approval to Mechanical General Arrangement drawings in B- code.

Mechanical Equipment data sheet submissions shall be made only after obtaining approval to Basic Engineering Package (BEP's) Design- Drawings and relevant Mechanical General Arrangement drawings.

All relevant detailed structural designs and detailed engineering drawings shall be prepared in compliance with the approved Civil GA guideline drawings from all related disciplines (i.e. Process, Mechanical, Electrical, Instrumentation etc.., whenever applicable) for all related structural components as required.

The lists provided below shall not be considered comprehensive. The bidder shall be responsible for including any and all drawings and information for any and all works that may be necessary for full and complete definition or clarification of the design, regardless of whether or not such drawings, information, or works are explicitly included in the lists below or elsewhere in these bid documents.

The Construction Documents shall be used for the construction of the Works and shall inter alia comprise:

(a) Civil

Site layouts for STP and SPS providing information on levels and detailing the location of:

- Detailed List of Units including Unit Dimensions/ Free Boards.
- General arrangements and main sections of all plant areas;
- Plans, elevations and main sections of all structures and buildings;
- Buildings
- Storage tanks;
- Process plants;
- Transformer enclosures & foundation

- Roadways;
- Drainage (plant drainage, sanitation and storm water drainage, receiving lake details);
- Buried pipelines;
- Cable routes for direct in ground and ducted systems;

Detail drawings of:

- Cable and pipe work chambers;
- Buried pipe work;
- Pipe work connections;
- Contract interface;
- Reinforcement drawings;
- Bar bending schedules.

Calculations for:

- Detailed Structural Design calculation of all the units/ Structures;

(b) Mechanical

- Comprehensive Piping and Instrumentation Diagram (P&ID) including details of:
- pipeline sizes and materials;
- valve size and type;
- Equipment detail
- instrumentation;
- identification of controlling PLC.
- Detailed Plant Operation and Control Philosophy;
- Detailed Equipment list

Drawings:

Mechanical General Arrangement drawings shall be submitted only after approval of Basic Engineering Package (BEP's) Design drawing documents.

Civil drawings shall be submitted only after obtaining approval to Mechanical General Arrangement drawings in B- code.

Equipment data sheet submissions shall be made only after obtaining approval to Basic Engineering Package (BEP's) Design- Drawings and relevant mechanical GA drawing.

Outline dimensional drawing & Cross section Drawing (with Bill of Quantity and Material of construction) for the following items for STP, but not limited to:

1. Coarse Screens
2. Raw Sewage Pump set
3. Fine Screens
4. Belt Conveyor for screenings
5. Sluice valve – motorised
6. Sluice valve – manually operated
7. Non-Return valves
8. Knife Gate Valves
9. Dismantling joints
10. H.O.T & E.O.T Cranes
11. Sluice gate – Manual & Motorised
12. Dewatering Pump set
13. Grit removal equipment
14. Fine Bubble Diffused Aerators along with Grid
15. Process Air Blowers
16. SBR Unit
17. Submersible Mixers for Anaerobic and Anoxic zones
18. Chlorination system
19. Sludge pumps

20. Mixed Liquor Internal Recycle Pumps
21. Alum dosing system
22. Chlorination system
23. Online disc filters, glass media filtration, activated carbon adsorption and final disinfection and ozonation
23. Centrifuge
24. Sludge Thickner
25. Sludge Dryer Unit
26. Plant Drain Pumps
27. Plant Water Pumps

Graphs for all major pumps and blowers (including but not limited to Raw Sewage Pumps, Sludge Pumps, Process Air Blowers) :

- Pump Performance Curves : Q vs. H, speed, P, Efficiency, and NPSH
- ISO-efficiency curves of the pump model proposed

Motor Curve

(c) Electrical

Drawings

STP:

Single Line Diagram of Complete Electrical System for STP based on the equipments finalized by Mechanical and Process.

(1) Electrical Substation Layout of STP showing Panel locations, Transformer locations and Trench Layout.

(2) 11kV Switchgears

(a) Dimensional Drawing showing overall dimensions, plan, elevation and cable entry details.

(b) Complete assembly drawings of the Switchgear showing plan, elevation and typical sectional views, details of bus bars and location of cable end boxes and control cable terminal blocks for external wiring connections, etc.

(c) Foundation plan showing the location of channel sills, anchor bolts and anchors, floor plans and openings.

(d) Schematic power and control wiring diagrams along with control & interlock details, complete bill of materials indicating make, type, rating, setting etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciations etc.

(3) 3.3kV or 6.6 kV Switchgears

(a) Dimensional Drawing showing overall dimensions, plan, elevation and cable entry details.

(b) Complete assembly drawings of the Switchgear showing plan, elevation and typical sectional views, details of bus bars and location of cable end boxes and control cable terminal blocks for external wiring connections, etc.

(c) Foundation plan showing the location of channel sills, anchor bolts and anchors, floor plans and openings.

(d) Schematic power and control wiring diagrams along with control & interlock details, complete bill of materials indicating make, type, rating, setting etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciations etc.

(4) Diesel Generator Set

(a) GA Drawing showing overall dimensions, plan, elevation, sectional views, mounting arrangement, layout, make, type, rating etc of diesel engine, Alternator, Control panel, battery, battery charger etc.

(b) Single Line & Schematic diagrams showing details of Power & Control, Change over, AMF details, Synchronising details, interlocks, protections annunciations, battery, battery charger etc with make, type, rating, setting etc of various equipment, components etc.

(c) Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.

(d) Exhaust system with piping layout

(e) Day oil tank sizing with mounting arrangement details

(f) Fuel bulk storage tank sizing with mounting arrangement details

(g) Fuel supply system with pipe arrangement.

(5) 11 / 3.3 kV or 11/6.6kV Transformers

(a) General arrangement drawing of the transformer, showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights, quantity of oil, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals and ground etc.

(b) Rating, diagram and terminal marking, complete with polarity and vector group.

(c) Control wiring diagram for marshalling box.

(d) Foundation drawing with position of foundation bolts and depth.

(6) 11kV / 0.433 kV Transformers

(a) General arrangement drawing of the transformer, showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights, quantity of oil, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals and ground etc.

(b) Rating, diagram and terminal marking, complete with polarity and vector group.

(c) Control wiring diagram for marshalling box.

(d) Foundation drawing with position of foundation bolts and depth.

(7) L.T Panels, Distribution Boards, Power Control Centres, Power Motor Control Centres, Motor Control Centres etc.

(a) Dimensional Drawing showing overall dimensions, plan, elevation and cable entry details.

(b) Complete assembly drawings of the switchboard/distribution board / MCC showing plan, elevation and typical sectional views, details of busbars and location of power & control cable terminal blocks for external wiring connections, etc.

(c) Foundation plan showing the location of channel sills, anchor bolts and anchors, floor plans and openings.

(d) Schematic power and control wiring diagrams along with control & interlock details, complete bill of materials indicating make, type, rating, setting etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciations etc .

(e) Feeder Operation and Interlock logic.

(8) H.T & L.T Capacitor bank with Automatic Power Factor Correction Relay

(a) Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation, side view, sectional view and foundation details.

(b) Justification for number of steps for switching.

(c) Complete schematic and wiring diagrams for capacitor control panel.

(9) Variable Frequency Drives
  (a) Dimensional details with mounting arrangement.
  (b) Schematic power and control wiring diagrams along with control & interlock details, complete bill of materials indicating make, type, rating, setting etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciations etc.
  (c) Specific details of converter, inverter and harmonic control units.
(10) Battery and Battery Charger with D.C. Distribution board
  (a) Dimensioned general arrangement drawings
  (b) Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation details
  (c) Complete schematic and wiring diagrams
(11) Cabling System
  (a) Make and type of HT& LT Power and Control Cables.
  (b) Details of Installation of Cables in Trenches, on cable trays, directly buried Etc at all locations inside the plant.
  (c) Cable routing plan and section inside the plant.
  (d) 11kV Cable termination and mounting Kit Layout drawing.
(12) Lighting system
  (a) Make, type, rating etc of various fixtures, receptacles, switches etc in various premises.
  (b) Make, type, rating etc of various fixtures, lighting poles etc for street lighting and flood lighting.
  (c) Detailed Room wise Lighting Layout with Type of fixture details and Circuit diagram showing phase wise load distribution and interconnection between switches, fixtures, Lighting panel, receptacles etc.
  (d) Internal road Lighting and Area lighting layout with location of poles, details of fixtures and mounting.
  (e) Street Light pole details with Foundation details.
(13) Earthing System
  (a) Details such as material, sizes, etc. of the earth conductor and electrode pits.
  (b) Earthing layout drawing showing routing of main grid inside the plant with details of interconnection of equipment earthing to the grid and earth pits.
(14) Lightning Protection
  (a) Details such as Lightning Protection system comprising of air termination, down conductors, test links, earth pits etc.
  (b) Lightning protection layout showing the formation of lightning mesh/grid on roof top, routing of down conductors, connection with the earth pit
(15) Electrical Equipment and Panel Layout for STP.

Schedules

STP

(1) Cable schedules & bill of quantities
(2) Electrical Load and Power consumption schedule
(3) Junction box schedule
(4) Protection relay setting schedule.

Calculations

STP

(1) Detailed Electrical Load List prepared based on approved Equipment list from process and Mechanical
(2) Transformer sizing calculation based on approved Electrical load list
(3) D.G sizing calculation based on approved Electrical load list

(4) Specific Energy Consumption Calculations.
(5) Bus bar sizing calculation for 11 KV Switchgears, 3.3 kV Switchgears, 415 V Switchgears etc.
(6) Co-ordinated protection study.
(7) Fault level and Voltage Dip Calculations.
(8) Sizing of Capacitor banks.
(9) Non Segregated Bus Duct
  (a) Sizing of the bus bars vis-à-vis thermal capability to withstand rated Continuous current and one second short time current.
  (b) Spacing of the insulators vis-à-vis mechanical strength to withstand forces due to momentary short circuit current.
  (c) Heat loss and temperature rise calculations for conductor and enclosure. All formulae and other information from which the heat losses have been derived shall be enlisted.
(10) HT and LT Cable sizing.
(11) Earthing sizing calculation
(12) Room wise Lighting Calculation as per Lux level given in the specification.
(13) Building Lightning Protection and Earthing Sizing Calculation as per the latest standards.

(d) Control and Instrumentation

Drawings:
- power supply distribution single line and schematics diagrams (see note 1) for each control panel;
- internal and external (see note 2) general arrangement for each control panel (dimensional);
- Control panel wiring diagram, , relay logic diagram along with terminal block details;
- System configuration and layout diagram along with bill of material, program listings, block logic diagram and control logic write up for PLC;
- UPS and battery sizing calculations;
- control and instrumentation loop drawings (see note 3);
- instrument installation detail drawing (hook up, see note 4);
- cable block diagrams;
- cable routing/installation drawings;
- foundation and fixing details and trenches drawings;
- mimic general arrangement (full colour copies shall be provided).

Schedules:
- cable schedule;
- cable interconnection schedule;
- control and instrumentation load schedule for each control panel;
- I /O schedule;
- junction box schedule;
- instrument schedule with tag nos;
- instrumentation, process control set point schedule;
- instrument data sheets;

Documentation:
- functional design specification (FDS)(see note 5);
- Factory Acceptance Test (FAT document);
- Site Acceptance Test (SAT).document

Notes:
1. Schematic drawings shall include a comprehensive schedule of the components used in each switchboard, MCC and control panel including details of the type, manufacturer and rating of each component.
2. The external arrangement of each switchboard, MCC and control panel shall show the arrangement of all components including details of panel section, switch and instrument labels.

3. Control and instrumentation loop drawings shall show on a single drawing the complete circuit associated with an instrument or device including details and location of power supplies, cabling and terminations.
4. Hook up drawings shall detail how an instrument or device is installed.
5. See details later for requirements of the FDS.

Electrical control schematics, loop diagrams and schedules shall where practical be A3 size drawings; all other drawings shall be A1 size.

(e) Mechanical Building Services

Drawings:
- single line schematics for waste water system and drainage systems;
- general arrangement drawings showing the location of each mechanical building service plant item;
- general arrangement of ventilation systems;
- fixing details.

Schedule:
- plant data sheets with Equipment GA dimensional drawing, Foundation detail, Calculation and Manufacturer's Quality Assurance Plan;
- pipeline schedules;
- Valve schedules.

Calculations for:
- System & Equipment sizing.

The Engineer reserves the right to ask for additional Equipment/system information apart from the above to ascertain good system design and proper selection of Equipment.

3.16.6 As-Built Drawings

These drawings shall be compiled by the Contractor and shall constitute a permanent record of the Works as executed. These shall include all such drawings, schedules, documentation and calculations as necessary for a complete understanding of the Works design, operation and maintenance.

The As-Built Drawings shall consist of the fully up-dated versions of the approved Construction Documents incorporating any additional information which will assist the Employer in operating, maintaining and if necessary modifying or extending the Works at a later date. These drawings should extend and supplement the information given in the Operating and Maintenance Manuals.

A3 and smaller sized As-Built Drawings shall be provided on durable paper for reproduction by photocopier. As-Built Drawings larger than A3 sized shall be provided as a paper copy and also produced in the form of black lines on a durable translucent film from which further paper prints can be taken by others as required. In addition drawings shall be provided as an AutoCAD software copy in editable form in Compact Disc (CD) in two sets.

Other related information such as Technical Proposal as per clause 3.16.5 and Section 8 - Technical Schedule but not limited to, shall be provided in hardcopy as well as editable softcopy format (Microsoft Word, Excel, Access, or Project).

3.17 Operating and Maintenance Manuals

3.17.1 General

The Contractor shall compile operating, maintenance and overhauling instructions for the whole of the Plant.

The instructions shall consist of one volume of:

(a) General descriptive text (including drawings for illustration) of the Works described section by section.
(b) Complete operational instructions for the sewage treatment plant. This shall be termed the Operators Manual. It shall be aimed at the operational staff and shall be written in clear unambiguous text complete with drawings which necessary for clarification of any issues. The manual shall comprehensively detail what to do on a day to day basis and also what to do in the event of faults develop. It shall in addition provide a complete list of the process maintenance tasks the operator should carry out including the intervals between these tasks.
(c) Essential instructions for mechanical and electrical maintenance of the Plant. These instructions shall be short and concise and set out in a consolidated schedule the inspection, lubrication, cleaning and any other type of servicing operations required. The Contractor shall prepare typical maintenance log sheets that the Employer can subsequently use for daily, weekly, monthly or other periodic maintenance and shall form record sheets of plant maintenance operations.
(d) Instructions for use of skilled maintenance personnel in fault location, carrying out routine replacements, withdrawing, dismantling, overhauling, re-assembling and testing the various items of Plant.
(e) Manufacturer's Technical Documentation subdivided into categories for:
    - civil;
    - process;
    - electrical;
    - electrical building services;
    - mechanical building services;
    - Instrumentation and control.
(f) Civil As-Built Drawings.
(g) Comprising the FDS and PLC code.
(h) Electrical As-Built Drawings: The electrical drawings shall be complete sets including all information necessary for maintenance and spares replacement.
(i) Control and instrumentation As-Built Drawings: The drawings shall be complete sets including all information necessary for maintenance and spares replacement.
(j) Mechanical As-Built Drawings: The mechanical drawings shall be complete sets including all information necessary for maintenance and spares replacement.
(k) Electrical and mechanical building services As-Built Drawings: The drawings shall be complete sets including all information necessary for maintenance and spares replacement.
(l) FAT records for the Plants and Works.
(m) SAT records for the Plants and Works.

Each volume shall be subdivided (relating to areas of plant) into sub sections or sub-volumes in order to ease the location of plant details. Each volume or sub volume shall be provided with a comprehensive index for the volume or sub-volume concerned and the O & M manual as a whole.

Each volume shall be enclosed within A4 and A3 ring binders having tough grease resistant covers suitable for use on site and designed to permit the easy removal and insertion of the contents. The front cover and spine of each volume shall show details of the project, Employer, Engineer and a volume title.

Text shall generally be enclosed in A4 ring binders, A3 drawings shall be enclosed within A3 ring binders except where they accompanies A4 text in which case they shall be folded. A1 drawings shall generally be folded and enclose in A4 box files. Where A1 drawings accompany text they shall be folded and enclosed in an A4 plastic wallet, one wallet per drawing.

3.18 Submission of Documents and Drawings

The Contractor shall supply to the Engineer 5 (five) copies each of the drawings and design calculations for the process and sizing of all components of the System including architectural, structural,

mechanical, electrical and instrumentation equipment, supported by flow diagrams and general arrangement drawings for approval.

The Engineer may require the Contractor to submit for approval additional drawings if they are necessary to enable him to satisfy himself that the items are well designed, that they comply with the Employer's Requirements and that they are suitable for their intended purpose. These drawings shall form the agreed basis for the execution of the Works. If an approved drawing is revised, revised copies shall be submitted for approval as above and no such revised drawing shall be used for the purposes of the Contract until it has been approved in place of the earlier issue of the drawing.

The Employer shall arrange to send observations if necessary within 28 (twenty eight) working days of submission of the design and drawings for modifications to the Contractor. The Contractor shall incorporate all necessary comments of the Engineer in the above design and drawings, if any, and shall re-submit further 5 (five) copies each of the revised designs and drawings within 10 (ten) days for the final approval of the Engineer. The Contractor shall thereafter submit 8 (eight) copies each of the approved designs and 8 (eight) copies each of the approved drawings together with one copy each of the reproducible tracings. The Engineer will return 2 (two) approved copies to the Contractor and retain 6 (six) for the Engineer's office and field use.

If the submissions require more then one round of revision on account of incomplete compliance from Contractor, the delay will be on account of the Contractor. If new observations are given by the Engineer, the Contractor will be entitled to take an additional 10 (ten) days period for compliance.

The Engineer will signify his approval or disapproval of the Preliminary Phase Drawings / Construction Documents within 28 (twenty eight) working days of each submission.

The above time line provisions/considerations for the Engineering (Design-Drawing Documents) review by the engineer are the minimum requirements and forms a guidance only whereas the actual time period required for review is subject to the quantity (including quality) of submissions.

Also document submissions shall be in a progressive manner and in the detailed /required sequence /priority including the Basic Engineering Documents and also all submissions shall be in relation to the /correlated with the prioritized construction activities i.e., to say, all Engineering (Design Drawing Document) to correlate with the construction activities /priorities including the related orderly/sequential equipments/procurement requirements and no pre-mature/parallel/advance/non-sequential document submittals shall be allowed/entertained/accepted. All subsequent documents shall be submitted/accepted only upon clearance of the preceding related documents (for Instance-Investigation-Process Design-Plant Layout-Hydraulics-P&IDs-Mechanical Gas-Civil Gas-Structural Designs etc).

It shall be the responsibility of the contractor to obtain timely clearances/approvals for all the design drawings and related documents.

The design review meetings shall be attended by the contractor's representative and design Engineers from contractor whose curriculum Vitae (CV) submitted and accepted by engineer vide Technical schedule-I in Technical Bid Evaluation or Equivalent Engineer(s) with the minimum qualification and experience requirement mentioned in Technical Schedule-I are only accepted to attend meetings.

The structural designs shall be submitted along with STAAD files (input and output).

The Construction Documents are certified Drawings submitted by the Contractor to the Employer or Engineer during the course of the Contract for approval. Construction Documents shall be submitted in accordance with the timetable set down in the Work Programme.

Approval of drawings by the Engineer shall not be held to relieve the Contractor of his responsibilities under the Contract.

The construction drawings shall be submitted in A3 / A1 sized drawing papers and to readable scale.

The Engineer will not permit construction to start on a part or section of the Works unless Construction Documents for that part or section have been approved.

Draft copies of the O & M Manuals shall be submitted to the Engineer for his approval at least 56 (fifty six) calendar days prior to the commencement of Tests on Completion.

The Engineer will signify his approval or disapproval of the O & M Manuals within 28 (twenty eight) calendar days of submission.

Draft As-Built Drawings shall be submitted 56 calendar days prior to the commencement of Tests on Completion.

The Engineer will signify his approval or disapproval of the As-Built Drawings within 28 (twenty eight) calendar days of submission.

The Final As-Built Drawings shall be submitted prior to the issue of any Taking Over Certificate.

To remove doubt the submission dates referred to above shall be the dates on which the drawings and documents are received by the Engineer.

3.19 Notice of Operations

The Contractor shall give full and complete written notice of all important operations to the Engineer sufficiently in advance to enable the Engineer to make such arrangements as the Engineer may consider necessary for inspection and for any other purpose. The Contractor shall not start any important operation without the written approval of the Engineer.

3.20 Protection of Existing Installations

The Contractor shall apply to the Engineer in writing at least 28 days before starting any work that involves interference with existing structures, equipment, etc. The Contractor shall not execute such work until he has received permission to proceed, in writing from the Engineer.

The Contractor shall ensure that no earth, debris or rock is deposited on public or private roads or rights of way as a result of the Works and all vehicles leaving the Site shall be cleaned accordingly.

3.21 Protection of Existing Public and Private Services

The Contractor shall notify all public authorities, utility companies and private owners of proposed works that will affect them not less than two weeks before commencing the works.

The Contractor shall adequately protect, uphold, maintain and prevent damage to all services and shall not interfere with their operation without the prior consent of the public authorities, utility companies, private owners, or the Engineer as appropriate.

If any damage to services results from the execution of the Works, the Contractor shall immediately:

(a) Notify the Engineer and appropriate public authority, utility company or private owner.
(b) Make arrangements for the damage to be made good without delay to the satisfaction of the public authorities, utility company or private owner as appropriate. The Contractor shall be liable for all costs for making good such damage.

The Engineer may issue instructions or make other such arrangements as he deems necessary, to repair rapidly any essential services damaged during the execution of the Contract. Such arrangements shall not affect any liability to pay for making good the damage.

3.22 Reinstatement and Compensation for Damage to Persons or Property

The Contractor shall reinstate all properties whether public or private which are damaged in consequence of the construction and maintenance of the Works to a condition as specified and at least equal to that obtaining before his first entry on them.

If in the opinion of the Engineer the Contractor shall have failed to take reasonable and prompt action to discharge his obligations in the matter of reinstatement, the Engineer will inform the Contractor in writing of his opinion, in which circumstances the Employer reserves the right to employ others to do the necessary work of reinstatement and to deduct the cost thereof as certified by the Engineer from any money due or which shall become due from the Employer to the Contractor.

The Contractor shall refer to the Employer without delay all claims, which may be considered to fall within the exceptions listed in the Conditions of Contract.

3.23 Packing and Protection

Before any Plant is despatched from a manufacturer's factory it shall be adequately protected and packed to ensure that it will arrive on the Site in an undamaged condition. The methods employed for protection and packing must be suitable for withstanding the conditions which may be experienced during shipment, delivery to the Site and prolonged periods of storage in the open, whether the items are shipped in packing cases, crates or only partially protected according to their nature.

Bright parts and bearing surfaces shall be protected from corrosion by applying a rust preventive lacquer, high melting point grease or similar temporary protection. A sufficient quantity of solvent shall be supplied with the plant to enable this coating to be removed on the Site.

All machined flanges and other mating surfaces shall be protected by means of wood templates. The bolts for securing these templates shall not be reused in the final installation.
No one crate or package shall contain items of Plant intended for incorporation in more than one part of the Works.
All items of Plant shall be clearly marked for identification against the packing list, which shall be placed in a waterproof envelope inside every packing case or crate.

Every packing case and crate shall be indelibly marked to show its weight, serial number, top and bottom, shipping marks and handling instructions or sling marks.

Electrical Plant shall be enclosed in sealed airtight packages with dehydrating material, before being placed in packing cases on shock-absorbent material and secured by means of battens.

3.24 Quality Assurance

3.24.1 Policy

In accordance with Clause 4.8 of the Conditions of Contract the Contractor shall apply the formal requirements of Quality Assurance to the design, supply, construction and maintenance of the Works. This shall be achieved through the implementation of a Quality System compliant with the requirements of BS 5750 or an equivalent International Standard.

Positive commitment to Quality Assurance shall be expressed in a formal policy statement given in the Contractor's Quality Manual.

3.24.2 Objectives

It shall be the stated aim of the Contractor to achieve and demonstrate the achievement of quality as expressed by `due care and diligence' of the design, supply, construction and maintenance of the Works as defined by the Employer's Requirements.

The criteria to define `due care and diligence' shall be explained in the Contractor's Quality Plan and shall embody all of the design, supply, construction and maintenance requirements of the Works.

3.24.3 Quality System

The Quality System shall be fully integrated for all of the Works.

This system will be defined by the organisational structure, responsibilities, activities, resources, and events that together demonstrate the capability of the Contractor to meet the stated quality requirements.

The Contractor shall ensure that all sub-contractors and sub-consultants establish quality systems and shall supply to the Employer such evidence as is necessary to demonstrate the effective implementation of a quality system in each sub-contractor or sub-consultant organisation.

The Quality System of the Contractor and of his sub-contractor and sub-consultants will be subject to periodic audits undertaken by the Engineer. The Engineer will give two weeks' notice of such audits that will involve a full assessment of the performance and efficiency of the Quality System and will include review of the feedback and records derived from the Contractor's monitoring and internal reviews.

On a day-to-day basis the Contractor shall afford reasonable availability of staff and documentation for the Engineer to assess the implementation of the Quality System. The Contractor shall ensure that all relevant personnel and documentation are available for such audits.

3.24.4 Quality Plan

The implementation of the Quality System shall be through the establishment of a comprehensive Quality Plan issued to and approved by the Engineer.

The documented procedures shall include but not be limited to:

- Management Procedures;
- Design;
- Supply/Procurement;
- Construction;
- Putting to work/Commissioning/Reliability Trial/Performance Test;
- Operator Training and Maintenance;
- Interface Control;
- Quality Performance, Monitoring and Review.

There shall be procedures to control transmission of information across all interfaces both internally (that is, within the Contractor's Quality System) and externally. Those of the latter shall include all Statutory Bodies, Authorities and the Engineer.

Formal assessment of any non-compliance with the Quality Plan shall be achieved through periodic reviews undertaken by a team appointed by the Contractor. All deficiencies shall be recorded and appropriate corrective measures shall be assessed, within an appropriate timescale, through subsequent formal reviews undertaken by the Contractor.

3.24.5 Quality Feedback

The system shall include for the reporting back, recording and incorporation into the system of deficiencies and remedial measures to correct them noted during the control of the project.

3.25 Environmental Protection

The Contractor shall minimize, as far as is practically possible, the effects of all his and his Subcontractors' activities upon the environment and shall implement and monitor measures to prevent:

(a) Contamination of surfaces, ground, groundwater, surface water and rivers,
(b) Emissions to air, including smells, gases, smoke, and dust.
(c) Unsanitary or unsafe storage or discharge to drain, sewer and surface waters,
(d) Unsanitary or unsafe storage or discharge of solid wastes,
(e) Noise,
(f) Visual intrusion, and
(g) Excessive energy and water consumption.

These requirements shall be met through the constant and careful attention of the Contractor's management of all Site and off-site activities, and by instruction to all staff and labour in these matters.

The Contractor shall appoint an Environmental Control Manager for the Works, who shall be responsible for preparing an Environmental Management Plan and ensuring its implementation by the Contractor after obtaining approval of the Engineer.

Implementation shall include for monitoring and reporting on the results of the above measures. Monitoring reports shall be in writing and submitted on a monthly basis as part of the monthly report referred to above. The report shall include a listing and summary of daily monitoring results on all aspects listed above.

All potentially affected areas of the Site, other areas used for or affected by the works and all adjacent or affected waterways shall be monitored and, where instructed by the Engineer, tested.

The Environmental Management Plan (EMP) shall identify the potential environmental impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach he will adopt in mitigating these environmental impacts to ensure that the residual impacts are minor and confined to a short period.

The EMP shall consider but not be limited to the following:

- The methods of materials delivery, storage, usage and disposal; equipment usage; and site activities to ensure they have minimal impact on the environment,
- Only environmentally safe products and practices shall be adopted in performing his works, and
- The Contractor shall comply with all of the statutes regarding environmental effects.

The EMP shall provide separate descriptions of its proposals for minimizing any adverse environmental impacts/effects during the construction phase and the subsequent operations and maintenance phase.

The EMP shall be provided in draft form within 28 days from the Notice to Commence, and shall be updated from time to time by the Contractor as agreed or required by the Engineer to ensure the objectives of environmental protection are fully met.

3.26 Safety

The Contractor shall prepare a Safety Plan and submit the same to the Engineer for approval within 28 days of receiving the Notice to Commence.

The Safety Plan shall be followed at all times by the Contractor and shall contain adequate control measures, in accordance with the relevant protection of property and local laws and regulations as well as internationally accepted good practice, for the prevention of accidents, fires and public nuisance.
The Safety Plan shall be implemented properly and diligently throughout the execution of the Works and during the operations and maintenance period.

The Contractor's Safety Plan shall make safety provision for, among other things:

(a) Deep excavations and collapsing sides in trench excavations,
(b) Scaffolds and overhead working,
(c) Working in confined spaces,
(d) Working in water,
(e) Contractor's Equipment, especially cranes,
(f) Hand held power tools,
(g) Electrical equipment,
(h) Hazardous chemicals, gases and fuels,
(i) The use of protective clothing, and
(j) The provision of first aid facilities.

The Safety Plan shall be developed to ensure zero fatal accidents and zero hazardous incidents/occurrences in all construction works. The Safety Plan shall include descriptions of the company's standard policies and procedures regarding its site organization and procedures, methods and frequency of conducting safety audits at the Site(s), record keeping and reporting, providing safety training for its personnel (including subcontractors), issue and mandatory use of safety equipment, and details of the qualifications and experience of the Bidder's proposed safety officers to be deployed at the Site(s). The Contractor shall provide separate descriptions in its Safety Plan covering the construction phase and the subsequent operations and maintenance phase.

The Contractor shall appoint a Full Time English speaking Safety Manager for the Works having experience in this field, who shall be responsible for implementing the Safety Plan. He shall be supported by at least two safety officers who are qualified for such safety works.

The Contractor shall ensure that his staff and labour and his Subcontractors are all fully trained in and aware of good and safe working practices.

The Contractor shall ensure that all precautions are taken to safeguard the general public and construction/operating staff from any danger.

All temporary and partially completed works shall be protected by way of barriers, lights, notices and the like.
All excavations and the like are to be protected by barriers at all times and adequately illuminated at night.
Warning and diversion signs concerning roadwork shall be suitably placed to give motorists ample warning. During the movement of heavy vehicles across roads or onto roads, men, bearing red flags, shall be in attendance to warn other road users and to generally control traffic in a safe manner.

The Safety Plan shall also consider requirements for warning and protection for other risks including overhead and underground cables, pipes or obstructions, or voids, openings, pits and trenches. The Contractor shall ensure that all appropriate measures are implemented.

The Safety Plan shall include a policy statement signed by the CEO or equivalent authority of the Organization declaring that safety and loss prevention shall be given the highest practicable priority in all aspects of the Contract. The Safety Plan shall be updated as necessary to cover the activities to be undertaken for operations and maintenance.

3.27 Co-ordination with concerned agencies

The Contractor, shall co-ordinate with other Departments/Agencies/Contractors; Bangalore Development Authority (BDA), KPTCL/BESCOM, BSNL, BBMP, BDA, LDA, KSPCB, KSEPA etc., during the course of implementation.

3.28 Disposal of Excavated Earth and Debris

The Contractor shall make his own arrangements to dispose off surplus excavated earth and debris at a site identified by the Contractor at his own cost and Bangalore Development Authority (BDA) will not be responsible in any manner. The Contractor shall not cause any inconvenience and nuisance in any manner to the public. The Contractor shall obtain necessary clearances / permissions at his own cost from police or any other statutory bodies / authorities concerned. Bangalore Development Authority (BDA) shall be indemnified from any issues arising out of this Contract.

Quoted rates shall be inclusive of all lead and lifting charges, etc., complete. Log book and photographs shall be maintained to record the truck details and for documentation purpose. The same shall be presented where requested by the concerned authorities.

End of Part 3

PART 4

GENERAL WORKMANSHIP, MATERIAL AND DESIGN REQUIREMENTS FOR PLANT

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PART 4

GENERAL WORKMANSHIP, MATERIAL AND DESIGN REQUIREMENTS FOR PLANT

4.1 Introduction

This part of the Employer's Requirements sets out the standards of materials, workmanship and design to be used by the Contractor for Plant. Reference to any specific material or equipment does not necessarily imply that such material or equipment is to be included in the Works.

All Plant used for the Works shall, unless otherwise specified, comply with the provisions of this part. The names of the manufacturers of materials and equipment proposed for incorporation in the Works together with performance, capacities, certified test reports and other significant information pertaining to the same, shall be furnished when requested for consideration by the Engineer, who shall have power to reject any parts which in his opinion are unsatisfactory or not in compliance with the Specifications and such parts shall be replaced by the Contractor at no extra cost to the Employer.

4.2 Materials General

All materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfections and selected for long life and minimum maintenance.

All submerged moving parts of the Plant, or components such as pins and spindles, for example, of the submerged moving parts or the faces in contact with the parts shall be of corrosion resistant metals and all submerged fasteners, nuts and bolts shall be of SS316. All parts in direct contact with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall also maintain their properties without aging due to the passage of time, exposure to light or any other cause.

Where "stainless steel" is specified or used it shall have resistance to atmospheric corrosion not less than that provided by B.S.970, Grade 410 S21 for forgings and B.S. 3100, Grade 410-C-21 for castings. Particular attention shall be made to the prevention of seizure by fretting where two corrosion resistant metals are in contact, by the selection of materials of suitable relative hardness and surface finish and the application of lubricants. Where bronze is specified or used it shall be zinc free, to B.S. 1400, Group B- PB1.

Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, these shall be selected so that the bimetallic corrosion is as low as possible. The publication by H. M. Stationery Office (in the U.K.) entitled "Corrosion and its Prevention at bimetallic Contacts" shall be used as a guide.

4.3 Workmanship General

Workmanship and general finish shall be of first class commercial quality and in accordance with best workshop practice and shall provide what is generally recognised as waterworks finish as defined elsewhere.

All similar items of plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit all similar items of plant. Machining fits on renewable parts shall be accurate and to specified tolerances so that replacements made to manufacturer's drawings may be readily installed.

All equipment shall operate without excessive vibration and with minimum of noise. All revolving parts shall be dynamically balanced so that when running at all operating speeds and any load up to the maximum there shall be no vibration due to lack of balance.

All parts which can be worn or damaged by dust shall be totally enclosed in dust proof housings.

Dynamic balancing of rotary components shall be to the relevant standards. All bearings shall have L-10 rating life of minimum 16,000 hours.

All instruments used for the works whether for permanent installation or for checks/inspection at the Manufacturer's works or for checks/inspection at site shall be calibrated using standard reference instruments from institutions recognised by the Government such as "Institute for Design of Electrical Measuring Instruments (IDEMI), Mumbai.

All outdoor instruments shall be provided with locked, galvanised metallic enclosures of 2 mm thickness, suitably painted.

4.4 Design Life

All materials and equipment shall be designed for long life and shall be suitable for continuous 24 hour per days operation for prolonged periods with a minimum of maintenance and the Contractor may be called upon to demonstrate this for any component either by the service record of similar equipment elsewhere or by records of extensive type tests.

Routine maintenance and repair shall as far as possible, not require the services of highly skilled personnel.
Except for consumable items such as rubber bushings, gland packings, carbon brushes etc. which normally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than three years of continuous normal operation and where major dismantling is required to replace a part, such life shall be not less than ten years.

4.5 Welding

In all cases where welds are liable to be highly stressed the Contractor shall supply to the Engineer before fabrication commences detailed drawings of all welds and weld preparations proposed. No such welding shall be carried out before the Engineer has signified his approval of the details proposed. No alteration shall be made to any previously approved detail of weld preparation without prior approval of the Engineer.

Welding shall comply with B.S 5135.

Approval of welding procedures shall be as per B.S. EN 288-3:1992. Welders shall be qualified to B.S. EN 287-1:1992. All aspects of fabrication and examination procedures including pre/post heating treatment, electrodes, Non-Destructive Tests (NDT) shall be subject to approval of the Engineer.

Following codes shall apply for the NDTs:

B.S. 2600 : Radiography;
B.S. 3923 : Ultrasonic Test;
B.S. 6072 : Magnetic Particle Test;
B.S. 6443 : Penetrate Test.

The % welding test shall not be less than 20% at manufacturing and 10% at erection.

4.6 Castings

All cast iron shall be of standard grey close-grained quality to B.S.1452: 1977 Grade 220 or better. The structure of the castings shall be homogeneous and free from non-metallic inclusions and other injurious defects. All surfaces of castings which are not machined shall be smooth and shall be carefully fettled to remove all foundry irregularities.

Minor defects not exceeding 12.5 per cent of total metal thickness and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques. The Engineer shall be notified of larger defects and no repair welding of such defects shall be carried out without prior approval.

If the removal of metal for repair should reduce the stress resisting cross-section of the casting by more than 25 per cent, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 per cent, then that casting may be rejected.

Castings repaired by welding for major defects shall be stress relieved after such welding.

Non-destructive tests will be required for any casting containing defects whose extent cannot otherwise be judged, or to determine that repair welds have been properly made.

4.7 Instrument Components

Iron and steel parts shall in general be painted or galvanised as appropriate in accordance with the Specification. Indoor parts may alternatively have chromium or copper-nickel plating or other approved protective finish.

Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the poles of electro-magnets and the metal parts of relays and mechanisms shall be chromium or copper-nickel plated or have some other approved finish to prevent rust Cores, etc., which are built up of laminations or cannot for any other reason be antirust treated, shall have all exposed parts thoroughly cleaned and heavily enamelled, lacquered or compounded.

4.8 Safeguarding of Machinery

The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this Requirement shall remove the Contractors obligation from drawing the attention of the Engineer to any feature of the Works which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs which would increase the safety of the Plant.

The installation layout and plant design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of hot pipes, air vents and rotating machinery.

All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.

4.9 Rating Plates, Name plates and Labels

All equipment, apparatus and Plant shall be clearly labelled or fitted with nameplates and rating plates generally as follows:

4.9.1 Indoor Type Labels

(a) Labels for the outside of equipment shall be of a rigid type laminated and engraved plastic material, with black block capitals on a white background. The labels shall be fixed by non-rusting screws, or similar approved fixing device.

(b) Labelling inside equipment shall be as above except that a flexible self-adhesive type labelling may be used if suitable for the ambient temperatures and if not less than 12 mm in width.

4.9.2 Weatherproof Labels

These labels may be vitreous enamelled or brass. Plastic labels will not be accepted unless proof can be given that the labels can withstand the environmental conditions found at Site.

Vitreous enamelled labels shall be secured by brass or non-rusting roundhead screws, with brass and fibre washers in contact with the enamel front and back to prevent damage.

4.9.3 Name and Rating Plates

Each main and auxiliary item of Plant shall have permanently attached to it in a conspicuous position a nameplate and a rating plate. Upon these shall be engraved the manufacturer's name, type and serial number of Plant, details of the loading and duty at which the item of Plant has been designed to operate, and such diagrams as may be required by the Engineer. All indicating and operating devices shall have securely attached to them or marked upon them a designation as to their function and proper manner of use. Provision shall be made to incorporate descriptive numbering codes as indicated on the Record Drawings. Details of proposed plates, labels and inscriptions shall be submitted to the Engineer for approval before manufacture.

4.10 Lubrication

A complete schedule of recommended oils and other lubricants shall be furnished by the contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the Engineer for approval before incorporation in the instruction manuals. In the case of grease lubricated roller type bearing for electric motors a lithium base grease is shall be used unless otherwise recommended by the manufacturer.

Where lubrication is effected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment of recharging. Frequent, for this purpose means more than once a week and grease systems having shorter periods between greasing should be avoided. Where necessary for accessibility grease nipples shall be placed at the end of the extension piping, and, when a number of such points can be grouped conveniently, the nipples shall be brought to a common place mounted in a convenient position. Button head type nipples shall be used for normal grease and all grease nipples shall be of the same size and type for every part of the Plant. Arrangements shall be provided to prevent bearings being overfilled with either grease or oil.

Where more than one special grease is required a grease gun for each special type shall be supplied and permanently labelled.

Oil lubricated bearings shall be provided with an oil reservoir capable of automatically maintaining the correct oil level within the bearings. It must not be necessary to shut down the pump in order to see the oil level or to add oil to the bearings.

Oil sumps shall be fitted with oil level indicators of the sight glass type, or where this is not practicable, with dipsticks. The indicators shall show the level at all temperatures likely to be experienced in service. The normal, maximum and minimum levels at 20°C shall be clearly visible in the sight glass type from the normal access floor to the particular item of plant, and they shall be easily dismantled for cleaning.

All sight glasses shall be firmly held and enclosed in metal protection in such manner that they cannot be accidentally dislodged.

All lubrication systems shall be designed so as not to present a fire hazard and particular care shall be taken to prevent leakage of lubricants and to avoid leaking lubricants coming into contact with any electrical equipment, heated surfaces or another potential source of fire.

The Contractor shall supply flushing oil for each lubrication system when an item of plant is ready for preliminary running and a sufficient quantity of the approved lubricants for setting to work and for the commercial operation of the Plant for two years after the Taking over Certificate has been issued.

4.11 Initial Changes of Oil, Grease, etc.

The initial changes of oil, grease, electrolyte and similar materials necessary for the correct setting to work and operation of the Plant shall be included in the appropriate Plant item.

4.12 Non-metallic Materials

Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation shall be treated, with an approved fungicide. Sleeving and fabrics treated with linseed oil varnish will not be permitted.

The use of organic materials shall be avoided as far as possible but where these have to be used they shall be treated to make them fire resistant and non-flame propagating.

The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or other approved hardwood which is resistant to fungal decay and other blemishes. All woodwork shall be treated to protect it against damage by fire, moisture, fungus, vermin, insect, bacteria or chemical attack, unless it is naturally resistant to all these. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings on wood shall be of non-ferrous material. Adhesives shall be specially selected to ensure the use of types which are impervious to moisture and fungus growth. Synthetic resin cement shall be used for joining wood.

4.13 Engineering Hardware

Nuts, bolts, studs and washers for incorporation in the Works shall conform to the requirements of the appropriate Indian or other approved standard. Nuts and bolts for pressure fittings shall be of the best quality steel machined on the shank and under the head and nut.

Bolts shall be of such a length that one thread shall show through the nut when in the fully tightened condition.

Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the screwed portion of such a diameter that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Washers, locking devices and anti-vibration fittings shall be provided where necessary to ensure that no bending stress is caused in the bolt.

Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt does not exceed half the yield stress of the material under all conditions.

All bolts, nuts and screws which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel.

The Contractor shall supply all holding down, alignment and levelling bolts complete with anchorages, nuts, washers and packings required to attach the Plant to its foundation, and all bedplates, frames and other structural parts necessary to spread the loads transmitted by the Plant to concrete foundations without exceeding the design stresses.

Unless otherwise necessary to meet special requirements all thread shall be of preferred metric sizes with standard coarse threads.

ISO metric black hexagon bolts, nuts and screws shall comply with SII 0589-81, or ISO 885, ISO 888, ISO 898-1 and -2.

ISO metric precision hexagon bolts, nuts and screws shall comply with ISO 272, ISO 4759-1, ISO 885, ISO 888, ISO 898-1 and -2 or ASTM F-593, ASTM F-468 M, strength grade 8.8.

The dimensions of ISO metric countersunk head bolts screws, and hexagon nuts shall comply with ISO 225, or ISO 888, ISO 898-I.

Plain steel washers for use with ISO metric bolts shall comply with ISO 887 or ASTM F-844.

Taper steel washers shall comply with ASTM F-844 and ASTM F-436.

4.14 Instruments

Unless otherwise specified, any indicating and recording instruments supplied under the Contract shall be approved by the Engineer. They shall be flush-mounted pattern with dust- and moisture-proof covers and shall be suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks.

Indicating instruments shall be of the dial type and shall be provided with a readily accessible zero adjustment.

Dials in general shall be white with black markings and not subject to fading. Scales shall be of such material that no peeling or discoloration will take place with age under humid conditions.

Motor ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale.

Steel screws, when used, shall be zinc, cadmium or chromium-plated, or where plating is not possible due to tolerance limitations, shall be of stainless steel. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be non-rusting materials, e.g. phosphor-bronze or nickel-silver, as far as possible. Pivots and other parts for which non-ferrous material is unsuitable shall be of stainless steel.

Pressure gauges shall be not less than 150 mm diameter unless otherwise approved. The internal components shall be of stainless steel, bronze or some other corrosion resistant material other than aluminium. The gauges may be mounted directly on the pipe work or side by side on a board or panel. Each pressure gauge shall be fitted with a stop cock immediately adjacent to the gauge, and all pressure gauge piping shall be fitted with an isolating valve at each point of connection to the main system. Where pressure gauges are mounted on panels, the isolating valve shall be suitable for the connection of a test gauge. Stop cocks of gauges shall be clearly identified by means of separate labels of approved type and lettering.

All fixed pipes below 25 mm nominal bore shall be compression jointed heavy gauge copper where this material is suitable. In other cases pipe materials are to be approved by the Engineer. All pressure gauges shall be fitted with an air release cock and hydraulic pressure snubbers to protect them against shock pressures.

4.15 Noise and Vibration

The noise level produced by any equipment like pump sets, compressor sets and blower sets shall not exceed 85 dBA measured at a distance of 1.86 m from the outline of the equipment. At the time of operation, the mechanical vibration shall not exceed the limits given below, at recommended points of measurement as per ISO 2372-1974 with Amendment 1-1983.

Equipment	Velocity of Vibration mm/sec
All rotating equipment not having reciprocating parts with motor KW less than or equal to 15 KW	1.12
All rotating equipment not having reciprocating parts with motor KW more than 15 KW and less than or equal to 75 KW	1.8
All rotating equipment not having reciprocating parts with motor KW greater than 75 KW	2.8

4.16 Pipe work and Layout

In general all pipes and fittings shall be steel or ductile iron with flanges to BS EN 1092-1/ BS 4504. Where steel and cast flanges are mated together the steel flange shall be machined over its full face, after welding to its respective pipe is completed.

Flexible joints shall be provided to facilitate installation and removal and/or differential movement of plant. Where required, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the pipe work as a whole.

The pipe work shall be laid out and designed such as to facilitate its erection, painting in situ, dismantling of any section for maintenance and to give a constant and uniform flow of working fluid with a minimum loss in head. Where steel pipe work is used the number of flanges is to be kept to a minimum with the size of each unit of pipe work determined by the ease of handling, installation and general appearance of the completed pipe system. Positions of flanges shall take into account any necessary concrete pipe supports or thrust blocks.

Facilities shall be provided for draining the pipe system. Where a pipe passes through a wall, retaining wall or is subject to thrust it shall incorporate a puddle flange which shall conform to the dimensions stated in BS EN 1092-1/ BS 4504 but remain undrilled.

Unless otherwise specified, nuts, bolts and washers for pipe work shall conform to the requirements of BS EN 1092-1/BS 4504.

Bolts shall be of sufficient length that one thread shall show through the nut when in the fully tightened condition.

4.17 Gaskets and Joint Rings

Joint rings shall be manufactured to conform to BS 2494 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80oC.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any constituent soluble in water of the quality stated in the Requirements, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

4.18 Steelwork

Any small areas of chequer plating or similar covering that are necessary to cover gaps between items of Plant and the surrounding structure, and any access ladders, platforms and handrails that must be attached to items of Plant to facilitate operation, inspection or maintenance, shall be supplied and erected by the Contractor.

The Contractor shall include in his Contract for providing adequate means of access to all hand wheels, sight glasses, gauges, lubrication points and any other items to which access is necessary for routine maintenance.

Handrails shall consist of double ball forged steel standards with tubular rails, hot dip galvanised in accordance with BS 729.

Chequer plating shall be of `Durbar' or other non-slip pattern, not less than 4.5 mm thick (exclusive of pattern) and hot dipped galvanised after fabrication in accordance with BS 729.

Aluminium alloy flooring may be offered as an alternative, manufactured in accordance with BS 1470, material H30 TB.

4.19 Spare parts

The spares shall comprise an adequate stock of the parts likely to be needed as routine replacements together with any major items or components which it may be desirable to hold in order to facilitate or expedite repair during O&M period of five years.

The Contractor shall supply the spare parts required for the continuous operation of the Works for the minimum period of 101 Five years. The cost of spare parts shall be paid as per the quoted price given in price schedule 6 – O&M prices. These prices shall be included in tender evaluation.

Spare parts shall be new and strictly interchangeable with the parts for which they are intended to be replacements and shall be treated and packed for long storage under the climatic conditions prevailing at the site. Spare parts to be supplied under this contract shall be interchangeable where possible within the treatment plants constructed under this contract.

Spare parts shall be packed separately from the main Plant in packages or containers designed to preserve the spares from the effects of long term storage under the ambient conditions specified. Any items that cannot be packed in this way must be protected from corrosion by applying temporary protective coatings and shielded from mechanical damage. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose, and when more than one spare is packed in a single case or other container, a general description of its contents shall be shown on the outside of such case or container and a detailed list enclosed. All cases, containers and other packages shall be marked and numbered in an approved manner for purposes of identification.

All cases, containers or other packages are liable to be opened for such examination as the Engineer may require and packing shall be designed to facilitate opening and thereafter repacking.

The Contractor may use spare parts provided under the Contract to replace failed parts prior to the issue of the Performance Certificate for the Works. However the Contractor shall be responsible for replacing those parts used with identical parts at no cost to the Employer.

The Contractor shall also supply the details of recommended spare parts and quantity required for the continuous and successful operation of the Works and after completion of the mandatory 05 years O&M period. Based on the consumption of spares during the 05 year O&M period, the Employer may need additional spares which will be purchased at the end of O&M period at prices quoted.

"Spares accompanied by technical details/leaflets etc. shall be delivered to site before the start of commissioning tests. Spare parts shall be indicated in the assembly drawings of respective plant items with clear details of part numbers. Contractor shall also furnish the manufacturers recommendations on spares for respective plant items."

4.20 Tools and test Equipments

A complete set of necessary special tools and test equipment shall be supplied by the Contractor to enable any erection, dismantling or testing to be carried out on any part of the Plant, whether of an electrical, mechanical or any other nature during the life of the Plant. Brand new tools and equipment shall be supplied at the end of O&M contract at no cost to Bangalore Development Authority (BDA). The cost of Tools and Test equipment shall deemed be covered under the O&M cost in price schedule.

The tools and test equipment shall not be used for the erection of the Plant and except that the Engineer may call upon the Contractor to demonstrate their use or effectiveness, they must be handed over to the Purchaser/Employer in a completely new and unused condition. Should the Contractor require any such tools and test equipment at the site during erection, he shall provide his own.

The tools for each different type of equipment shall be contained in a suitable box clearly marked or labelled with its description. Each tool shall be identified and a list of tools shall be affixed to the inside of the box lid. Each set of tools shall be supplied with the equipment with which it is associated.

The test equipment shall include only special purpose items essential to the testing or recalibration of related items of Plant.

The Contractor will be permitted to utilise the overhead gantry cranes supplied under this Contract for the purposes of installing the equipment in his supply. The Contractor shall be responsible for making all arrangements for the electricity supply to operate the cranes and for their service, maintenance and repairs. On completion of the installation and before hand over of the Plant the Contractor shall restore the cranes to an as new condition by the replacement of all worn or defective components.

All special tools and test equipment necessary for overhauling the Plant and testing its performance shall be included and mounted in suitably designed cabinets with lockable doors and shall be stored in maintenance workshop. Racks and clips shall be provided for individual items with outline markings and labels to show where any equipment is missing.

The tools provided shall include clamps, wrenches, lifting lugs, grease guns, gauges test rigs, jigs or extractors which may be required for the life of Plant. All tools and test equipment shall be clearly detailed with size/capacity etc.

The Maintenance workshop shall include all necessary machine tools, welding machines (electric/acetylene gas), lifting equipment/tools/shackles required for carrying out periodic and breakdown maintenance of plant items.

4.21 Protection and Packaging for Transportation

Before any Plant is dispatched from a manufacturer's works it shall be properly prepared and packed.

Prior to dispatch all Plant shall be adequately protected by painting or by other approved means for the whole period of, transit storages and erection, against corrosion and incidental damage, including the effects of vermin, sunlight, rain, high temperatures and humid atmospheres. The Contractor shall be held responsible for the Plant being so packed and/or protected as to ensure that it reaches the site intact and undamaged. The Plant shall be packed to withstand rough handling in transit and all packages shall be suitable for storage including possible delays in transit.

The Contractor shall be deemed to have included in the Schedule of Prices for all materials and packing cases necessary for the safe package, conveyance and delivery of the Plant.

The flanges of pipes, valves and fittings shall be protected by wooden discs attached by means of service bolts (which shall not be used at Site) or by other approved means. The sleeves and flanges of flexible couplings shall be bundled by wire. Cases containing rubber rings, bolts and other small items shall not normally weigh more that 500 kg gross.

No one package or bundle shall contain items of Plant intended for incorporation in more than one section of the Works. All items of Plant shall be clearly marked for identification against the packing list.

Every crate or package shall contain a packing list in a water proof envelope. A duplicate copy of the packing list shall be sent by post to the Engineer's Representative at Site.

All crates, packages, etc., shall be clearly marked with a waterproof material to show the weight, and where the slings should be attached, and shall also have an indelible identification mark relating them to the packing lists.

End of Part 4

PART 5

PROCESS REQUIREMENT

PART 5

PROCESS REQUIREMENTS

5.1 Sewage Treatment Plants

Process requirements for the following STP are included in this contract and are described here in Part 5 – "Process Requirements"

Sl. No.	Component Name	Ultimate Build out Design Average Capacity (MLD)	Initial Design Average Capacity (MLD)	Treatment Process
1	Proposed STP-1 25 MLD Capacity	25	25	Waste Water Treatment Process with primary treatment in the form of screening and de -gritting, oil & grease removal, secondary treatment in the form of Sequencing Batch Reactor Process (SBR) and tertiary treatment consist of on-line disc filters, sand filtration, activated carbon adsorption and final disinfection to achieve standards of discharge as per NGT norms with specific reference to TN, COB, Phosphorus and TSS
2	Proposed STP-2 50 MLD capacity	50	50	

Note: The design peak factor for all unit operations like Receiving chamber, inlet chambers, medium screens, fine screens, grit chambers is 2.25 including all piping and channel

5.2 Influent Wastewater Characteristics

The influent wastewater characteristics to be used as the basis of design

Influent Wastewater Characteristics	Units	Design basis
pH		7.0 - 8.5
BOD	mg/L	360
COD	mg/L	850
TSS	mg/L	238
VSS	mg/L	140
TKN	mg/L	65
NH_4-N	mg/L	54
Total Phosphorus	mg/L	5 to 7
Feacal Coliform	MPN/100 mL	7×10^8
Total Coliform	MPN/100 mL	1×10^9

Alkalinity	mg/L as $CaCO_3$	100
Min. Sewage Temperature (Tmin)	^{O}C	18
Max. Sewage Temperature (Tmax)	^{O}C	27
Min. Ambient Temperature	^{O}C	15
Max. Ambient Temperature	^{O}C	38

5.3 Effluent Quality Requirements

The effluent quality requirements to be met

Treated Effluent Quality Requirements (at outlet of Chlorine Contact Tank)		
Item/ Parameter/ Description	Unit	Design Basis
pH - instantaneous range		6.5 - 9.0
BOD_5 at 20^0C	mg/L	10
COD - max monthly avg	mg/L	50
TSS - max monthly avg	mg/L	10
NH_4-N - max monthly avg	mg/L	5
N Total - max monthly avg	mg/L	10
Residual Chlorine - min instantaneous	mg/L	<1
Fecal Coliform - max monthly avg	MPN/100 mL	< 100
TP	mg/L	<1

5.4 Dewatered Sludge Quality Requirements

The dewatered sludge quality requirements to be met are listed bwlow

Treated Sludge Quality Requirements (Dewatered Sludge)		
Sludge Quality		dewatered sludge with sludge class B specified
Maximum Sludge VSS/TSS	%	70%
Minimum sludge TSS (dry solids)	% w/w	20%

5.5 Treatment Process

The main treatment process train in two modules for the STP shall consist of the major unit processes and components listed in Paragraph 5.13 – "Design/Sizing Criteria and Other Requirements". This list shall not be considered to be a comprehensive description. Contractor shall provide a complete, fully functional facility designed for proper, easy, operation and to meet the stated performance requirements. This shall include any and all additional, ancillary, supporting, or other processes, components, equipment, or other items necessary to achieve these objectives, regardless of whether such items are explicitly listed in these bid documents or not.

The design/sizing criteria, minimum number of units, and other requirements for the various unit processes and components are listed in Paragraph 5.13 –"Design/Sizing Criteria and Other Requirements", and in Part 11 – "Particular Mechanical Requirements" and shall be fully complied. In the absence of any criteria, CPHEEO manual 2012 holds good.

5.6 Demolition of Interfaces and Tie-Ins with Existing Facilities

Deleted .

5.7 Refurbishment of Existing Treatment Facilities – Delted

It is advised that contractor may visit the site to identify extent of refurbishment needed and same shall be submitted including planning, design and implementation of such refurbishment as part of Bid submission.

5.8 Plant Layout and Hydraulic Profile

A representative layout and estimated hydraulic profile of the STP is included these bid documents.

These drawings shall be considered representative only. In the event of any conflicts between information in the drawings and Part 5 – "Process Requirements", shall govern.

The Contractor shall ensure that the layouts and hydraulic profiles submitted as part of the Contractor's bid comply with the following specific constraints and all other requirements described in the Bid Documents:

- For all structures containing water or process liquid, the minimum freeboard (distance by which top of wall / bottom of slab in case of walkway or closed tank is higher than the maximum water surface level at receiving water high flood level and maximum daily flow) shall be 0.5 m unless specified otherwise. The maximum water level at peak plant flow with one unit of each unit process out of service shall be below the top of wall / structure.
- Contractor shall provide the STP all necessary facilities for manual bypass of the process liquid at various locations in the flow path as indicated below. These facilities are included in this contract and shall be provided regardless of whether or not they are shown in any drawings included in the contract document, shall be fully functional in all respects, and shall include any and all components necessary to safely and efficiently accomplish the intended bypass. Each bypass facility shall include, but not be limited to: (i) downward opening overflow weir gates or weir with sluice gates installed in the appropriate channel or structure from which the bypass is to be effected, (ii) an RCC channel or structure to receive the bypass flow over the weir gate, (iii) an appropriately sized buried (above ground piping will not be acceptable) pipe to carry the bypass flow from the channel or structure in (ii) above to a manhole or junction box in the STP's main outfall pipe.

  Bypass facilities as described above shall be provided at the following locations:

  - SPS Coarse Screen Effluent Channel to adjacent nala.
  - Grit Tank Effluent Channel to adjacent nala
  - Aeration Basin Influent Channel to adjacent nala

Topographical survey information, benchmarks, contour maps, geotechnical/soil investigations, and effluent receiving existing storage facility/water body/nala high flood level (HFL) elevations for STP site are included with these bid documents and/or available from Employer on request. However, Employer and Engineer make no guarantees or representations whatsoever regarding this information. Contractor's use of this information shall be at his own risk. Contractor shall independently obtain any and all site information necessary for proper planning, design, and operation of all components in the contract.

All aspects of Contractor's technical design shall also be subject to review and approval by Employer and Engineer.

5.9 Plant Layout and Orientation

The STP components shall be laid out and fully contained within the respective designated site boundaries so as to logically interface with any and all existing infrastructure that may be present at the site and that must remain in service. Contractor's proposed site layout shall clearly show the space

allocated for all plant components, including those components and/or unit processes that may be designated for future construction or installation. Setbacks and clearances from the site boundary shall be provided as appropriate and as required by building code law. All existing utilities (including water, sewer, power, or others, whether overhead or underground and whether physically located on the site or not) requiring to be relocated to accommodate the Contractor's proposed and approved site layout shall be relocated by the Contractor at no additional cost and without interrupting provision of such utility services to users and customers. Such relocations shall be fully coordinated with Bangalore Development Authority (BDA).

The plant layout shall adhere to the following general rules:

- Minimum clear distance provided to permit safe and convenient access for operation and maintenance shall be 3 m between adjacent treatment units or fixed structures and 1 m between pieces of equipment if possible
- An area adjacent to all mechanical equipment shall be provided as a maintenance lay down area
- All electrical equipment shall be located above the high flood level elevation for the site or for the effluent receiving nala/water body, whichever is higher.

5.10 Modular Design, Construction, and Operation for Reliability, Redundancy, Turndown, and Easy Future Expansion

The initial design capacity and the ultimate build out design capacity required are both specified in Paragraphs 5.1 for STP.

For all the components under this contract, the capacity to be provided shall be designed and constructed using multiple in two modules, suitably sized unit process modules to ensure reliability, redundancy, and appropriate turndown for optimum capacity utilisation and process efficiency. The minimum number of working and standby modules or units required for each component shall be as listed in Paragraph 5.13 – "Design/Sizing Criteria and Other Requirements".

5.11 General Design Requirements

The following general design requirements shall be met for SPS & STP. These requirements shall be fully met regardless of whether or not such requirements or any related components are shown in any drawings included in the contract documents.

- The Contractor shall perform a complete Hazardous Area Classification analysis per IS 5572 for, SPS and STP in this contract and shall submit a complete report of such analysis as well as Hazardous Area Classification Drawings that delineate boundaries of all classified areas and indicate the classification of each area. All electrical or other powered equipment, instrumentation, or components shall fully comply with all requirements of IS 5571.
- All components (including but not limited to equipment such as pumps, blowers, screens, diffusers, inline devices; instruments such as flow meters; and distribution and collection channels or pipes) shall be provided with appropriate isolation devices such as valves, gates, or other devices in order to allow isolation, drainage, cleaning, calibration, servicing, and maintenance of such components. Bypasses shall be provided around all flow meters and other in-line instrumentation such that the instrument can be isolated and removed for calibration and maintenance without interrupting the flow, regardless of whether or not such bypasses are shown in any drawings included in the contract documents.
- Where necessary, equipment shall be provided with acoustic, sound-dampening enclosures to limit ambient noise during normal operation to the limits detailed in the General Requirements.
- All equipment shall be arranged and buildings and structures designed to permit safe and easy access to and removal of all equipment.
- Fixed runways, lifting eyes, cranes, hoists, or other appropriate devices and means shall be provided to permit safe and easy removal of all equipment for maintenance or any other purpose

- All liquid or sludge flow distribution shall be accomplished using one of the following options only:
  - non-submerged (i.e. with a positive free fall from weir invert to the water surface on the downstream side) overflow weirs,
  - non-submerged downward opening overflow weir gates, or
  - automatic feedback flow control using inline flow measurement and modulated flow control valves with electrical actuators.

All gas / air flow distribution shall be using automatic feedback flow control using inline flow measurement and modulated flow control valves with electric actuators.

Any other means of flow distribution shall not be acceptable.

- All structures, whether liquid-holding or not, shall be designed such that they can be fully and completely drained and will not float or move when empty, because of groundwater buoyancy or any other reason. The structures shall be designed to counteract any possible floatation without the use of any type of groundwater pressure relief valves.
- The floors of all liquid-holding structures shall be appropriately sloped and trenches and drain sumps shall be provided at the bottoms of such slopes to facilitate complete drainage of liquid. Appropriate drain pipes and valves connected to the drain sump(s) shall be provided for all structures. Where the drain pipe connects to the structure, the top-of-pipe elevation shall be at least 150 mm lower than the lowest floor elevation for the structure. The drain piping shall be routed from the structure being drained to the Plant Drain Pump Station and shall be continuously sloped downward in the direction of flow with a minimum slope of 1 percent. For liquid-holding structures, the drain piping and fittings shall be sized such that the entire structure can be drained by gravity in no more than six (6) hours. The Plant Drain Pump Station, Plant Drain Pumps, and other related equipment and controls shall be designed and sized to allow draining of the structure with the largest volume from full to empty within six (6) hours. The highest design water level (High High Alarm) in the Plant Drain Pump Station wet well shall be at least 300 mm lower than the lowest pipe invert elevation amongst all drain pipes connecting to the wet well.
- Non-liquid-holding areas, structures, or buildings where leakage or other wet activities can occur, whether in normal use or during maintenance, shall be provided with covered drainage channels which shall direct the spillage either to a suitable gravity drain or to a sump equipped with standard dual submersible sump pumps discharging to the Plant Drain Pump Station.
- All channels carrying process liquid shall be fully covered with solid non-skid GRP cover plates (not grating) designed for human traffic live loads at a minimum and heavy vehicle live loads wherever the channel crosses traffic paths.
- Inlets into tanks, reactors, or other structures via pipes, channels, valves, or gates shall be designed such that the incoming flow does not cause any damage or excessive wear whatsoever to the structure or any equipment in the vicinity under any hydraulic condition, including but not limited to the condition when the structure is empty.
- All piping shall be of corrosion–resistant material appropriate for the service and shall be provided with interior lining, exterior coating, and other corrosion protection as appropriate. All piping shall be fully and adequately supported and braced to comply with all applicable codes and standards. All supporting hardware shall also be of corrosion-resistant material. The design of pipe supports and anchors shall fully account for static and dynamic vertical, lateral, longitudinal, and seismic loads, fluid flow, and thermal expansion. Seismic bracing, thrust restraints and/or thrust blocks, and appropriate expansion joints or loops shall be provided as needed. Pipe lengths and joints shall be assembled and arranged for ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes, by providing dismantling joints at regular intervals.
- For liquids and sludge, the minimum pipe flow velocity shall be no less than 0.6 m/s and the maximum pipe flow velocity shall be no more than 1.2 m/s for pumped suction and no more than 1.8 m/s for pumped discharge and the maximum pipe flow velocity shall be no more than 1.2 m/s for gravity flow. All mixed liquor and sludge lines shall be minimum 150 mm diameter for pump suction and minimum 200 mm for gravity in general and shall be provided with appropriate cleanouts and flushing arrangements for safe and easy flushing using high-pressure water.

- The normal pipeline peak flow velocity for water shall be not more than 1.8 m/s and for gases shall be not more than 12 m/s.
- All liquid service pipes shall be provided with appropriate means for safe and easy drainage of the pipes when not in service.
- All pipes shall be colour code banded and suitably labelled with the stream designation and direction of flow to enable individual lines to be identified throughout their run.
- Particular attention shall be paid to the layout of the chemical piping, which shall be arranged without clutter and shall be functional and neat in appearance. Generally, where piping is installed in ducts, it shall be supported not less than 150 mm clear of the floor.
- All piping routed under any type of structure or equipment shall be fully and completely encased in reinforced cement concrete, with the encasement thickness beyond the outer diameter of the pipe being at least 200 mm on all sides. The encasement shall extend along the pipe length for a minimum horizontal distance of 500 mm in each direction beyond the footprint of the overlying structure or equipment.
- All piping connecting to, entering, or exiting any and all structures shall be provided with appropriate restrained flexible connections and/or joints at all such interfaces with structures to allow for differential movement between pipe and structure in all directions without stressing or breaking the pipes.
- Appropriate restrained flexible connections and/or joints shall be provided for all pipes where they connect to any and all of the following:
  - Equipment such as pumps, blowers, or inline devices
  - Valve
  - Wall, floor, or roof penetrations
- Where piping or other materials susceptible to damage from ultraviolet radiation are employed, they shall be protected from such radiation through the use of appropriate additives and/or coatings and shall be physically shielded from direct sunlight at all times in their normal service location using enclosures, covers, canopies, roofs, and/or other similar means.
- Platforms, handrails/guardrails, ladders, and stairs shall be provided where necessary for proper, safe, and easy access to and/or operation of valves, gates, instruments, control panels, and other devices, equipment, or structures.
- Appropriate sampling ports and/or sampling valves shall be provided to allow easy, safe sampling of all process streams without spillage or contamination and without the need to interrupt normal operation.
- The influent flow meter and influent sampling location shall be selected such that the true influent flow and characteristics will be measured without inclusion of in-plant recycles or other extraneous streams. Separate flow measurement and sampling shall be provided for the recycle streams.
- Foam, scum, fats, oil, grease, or any other floating material removed from any location in the STP shall be completely removed from the process flow path along with waste, digested, and/or dewatered solids leaving the STP and shall under no circumstances be recycled or returned to any location in the plant.

5.12 Process and Facilities Description

This Process and Facilities description is intended to provide a general indication of the processes and types of facilities that the Contractor shall be required to design, construct, and operate, and applies to SPS & STP in this contract. The Contractor shall use this description together with other specific information for the SPS & STP provided elsewhere in these bid documents, including but not limited to Paragraph 5.13 – "Design/Sizing Criteria and Other Requirements", Part 11 – "Particular Mechanical Requirements", and Volume 4 – "Drawings", all of which are integral to this Process and Facilities Description and are incorporated herein by reference. The Contractor may propose alternate implementation details such as detailed site layouts and elevations of specific components. However, the Contractor shall strictly comply with the specified treatment concept, treatment unit processes, flow configuration (connectivity between unit processes and facilities), performance requirements (such as effluent and sludge quality and equipment efficiencies), and design criteria (such as design operating conditions, various process loading rates and/or detention times, volumes, and dimensions where specified) such as the minimum requirements in the paragraph 5.12 "Design/Sizing Criteria and other requirements".

Contractor should note that this particular contract shall include all of the components described in this "Process and Facilities Description". Components included in this specific contract are listed in Paragraph 5.13 – "Design/Sizing Criteria and Other Requirements".

5.12.1 Receiving Chamber, Mechanical Coarse Screen Channels & Raw Sewage Lifting Station

For the STP included in this contract that receives raw sewage directly from sewer, Bangalore Development Authority (BDA) shall be responsible for collecting and conveying the sewage through such sewer to an inlet manhole and/or chamber located within the STP boundary, as specified in this contract document. The Contractor for this contract shall construct the receiving chamber and coordinate the exact location and elevation of such chamber with Bangalore Development Authority (BDA). Bangalore Development Authority (BDA) will be responsible for the incoming pipe(s) to the chamber location. However, the Contractor shall be fully responsible for proper coordination to ensure proper alignments and interfaces and for proper implementation of all connections. If indicated elsewhere in this contract document, the chamber shall also provide a flow distribution function to distribute the incoming flow. The Contractor shall be fully responsible for proper coordination to ensure proper alignments and interfaces and for proper implementation of all connections.

For the SPS included in this contract that receives sewage from an inlet chamber included in this contract, the contractor shall be fully responsible for the entire scope of work for both the inlet chamber and SPS as specified in this contract document, as well as for all connecting piping, including proper alignment, interfacing, and implementation of all pipe connections at both ends.

5.12.1.1 SPS Coarse Screens

For the SPS included in this contract that receives raw sewage directly from Bangalore Development Authority (BDA) sewer, incoming sewage shall be conveyed from the receiving chamber to the coarse Screen influent channel via an appropriately sized gravity pipe or over appropriately sized downward opening overflow weir gate(s), and screened using coarsed Screens placed in deep concrete channels immediately upstream of the SPS wet well. An electronically controlled automatic jam removal system shall be provided in addition to the safety devices specified elsewhere in the document. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. A belt conveyor positioned above ground level shall convey the screenings through a SS304 chute to a screening collection Bins positioned at ground level. All Screens shall be provided with thimble mounted isolation Sluice gates both on upstream and downstream. And also isolation thimble mounted sluice gates shall be provided in inlet chamber for overflow arrangement.

5.12.1.2 SPS Wet Well

The SPS included in this contract shall be of the wet well type with submersible (non clog) pumps.

The screened sewage from the coarse Screens (located in SPS) shall be collected via appropriately sized channels or gravity pipes into a common channel or gravity pipe which shall connect to wet well.

The wet well shall be a circular or rectangular concrete structure, well shall be designed to be fully self-cleaning and prevent any accumulation of solids or debris under any and all flow conditions. well shall be provided with an adequate number of vents of adequate size to allow unrestricted changes in wet well liquid level. The vents shall be located in open areas exposed to the atmosphere and atleast 2m above top of pump room, and shall be terminated in "goosenecks" (inverted U fittings) with screens to prevent entry of foreign objects into the vent piping.

The wet well shall be provided with required capacity and number submersible sewage pumps for lifting the raw sewage to inlet chamber of Fine screen chamber. All the internal piping, pumping main including specials etc. shall be of DI material. The diameter of pumping main shall be selected such that when one number of working pump is in operation, the velocity of flow shall be minimum 0.60 m/sec.

The pumping main shall be provided with an electromagnetic flow meter with bypass arrangement to measure instantaneous and cumulative flows to STP. The pumping station shall be equipped with necessary mechanical hoist for lifting, moving and lowering the pumps during maintenance. The minimum height of pump house shall be 4.20 m up to soffit of roof beam. The pumping station shall be provided with access walkways / stairways protected with hand rail. Also the peripheral wall of screen channels shall be protected with hand rail all round. SS 316 rungs shall be provided for accessing the floor of inlet chamber, screen channels and pumping station well. The access manhole for well shall be min. 0.60 m x 0.60 m size and shall be of CI material. Exhaust fan shall be provided for pump house as per electrical requirements. All round the structure 100 mm thick, 600 wide, M: 20 plinth protection shall be provided.

5.12.1.3 SPS Pumps

For the SPS included in this contract, coarse-screened sewage shall be pumped by the SPS Pumps to the inlet chamber of Fine Screen Inlet Channel of STP as specified in the bid documents.

Pump operation shall be automatically controlled based on wet well level. The level sensing shall be done through ultrasonic level switches and level transmitters. The screen shall be provided with alarm for overload / blockage and shall be provided with a torque switch. In addition to above an adjustable timer based operation control system shall also be provided for regulating cleaning interval. The pumps shall be automated to work alternatively including standby and no pump shall work continuously for longer duration. In the event of sewage level in the sump well reaching minimum level due to stoppage of inflow all the pumps shall stop automatically. The same shall be accomplished using level switches and level transmitters hooked to a control system. Each pump shall be provided with an overload alarm.

5.12.2 Fine Screens

The Fine Screens shall receive coarse-screened sewage from the upstream SPS. An electronically controlled automatic jam removal system shall be provided in addition to the safety devices specified elsewhere in the document. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. A screw or belt conveyor positioned above ground level shall convey the screenings through a SS316 chute to a screening collection Bins positioned at ground level. All Screens shall be provided with thimble mounted isolation Sluice gates both on upstream and downstream.

The screenings shall be lifted mechanically upto top of the channel and directly discharged into portable wheel barrows. Two Nos. of wheel barrows shall be provided with each having 4.0 ft^3 capacity. A ramp shall be provided from finished ground to screen channel top for movement of wheel barrows. The screenings so collected shall be finally conveyed and disposed off at designated landfill sites identified by Bangalore Development Authority (BDA) / KSPCB in secured manner without causing any type of nuisance.

5.12.3 Grit Chamber and Distribution Chamber to SBR Tank

A complete grit removal facility shall be provided. All equipment and components necessary for a fully functional system shall be provided regardless of whether or not such items are specifically listed or described in the bid document. Dewatered grit shall be collected in a truck/tractor-trolley positioned at ground level below. De-gritted sewage shall exit the Grit Basins over the outlet weir. Liquid streams shall be returned to the de-gritted sewage stream or to the Plant Drain Pump Station.

The equipment shall be provided with alarm for overload / blockage and shall be provided with a torque switch. The dried grit shall be finally conveyed and disposed off at designated landfill sites identified by Bangalore Development Authority (BDA)/ KSPCB.

A Parshall flume shall be provided for flow measurement after the grit chambers.

The distribution chamber shall be square / rectangular in shape and shall be provided with suitable diameter DI K9 pipes for conveying de-gritted sewage to Sequencing Batch Reactor tanks. CI sluice gates shall be provided in the chamber to control flow through each tank. The gate operation shall be through electrical operated actuators and gate operation shall be controlled through SCADA.
The inlet chambers, screen channels, grit chambers and distribution chamber shall be provided with access walkways / stairways protected with hand rail. PVC encapsulated CI rungs shall be provided for accessing the floor of the channels and chambers. The structure shall be provided with a common RCC staircase for accessing the top from finished ground level.

5.12.4 Selector Chamber, Sequential Batch Reactor and Internal re-circulation / Excess Sludge Pumps

Sequencing Batch Reactor:
Screened and degritted sewage shall be fed into reactor for biological removal of BOD, suspended solids, COD, Nitrogen and Phosphorous. The technology shall work on cyclic/batch mode in a single unit having cyclic operation with phases as fill/aerate, anoxic mix, settle and Decant without overlap or simultaneous occurrence of any phases in a cycle. The fill volume in the tank shall be equal to decant volume and as such (1) the fraction of tank content removed during decanting and (2) the settle decant and aeration tank shall be as per design requirement. The operating cyclic shall be suitability selected to ensure adequate aeration, settlement and decanting to achieve the required effluent quality. Number of reactor shall suit sequential cycle time and volume of decanted flow from each unit.
The following core components in the treatment process must be designed as per the design basis and sizing as provided herein. No deviation is allowed in the specifications, design and sizing of these core components. Other unit operations is expected to be designed and sized based on CPHEEO manual 2012.
These components as listed are:

1. SBR process design, sizing and tanks
2. SBR aeration blower capacities
3. Tertiary filtration with three step process to achieve NGT norms
   a. step 1 : on line disc filter / on line auto wash filter
   b. step 2 : glass media filtration
   c. step 3: activated carbon adsorption filtration
4. Tertiary disinfection is to be done through chlorination first followed by final disinfection with or without ozonation.

5.12.7 Sludge Handlings And Management System

The sludge from the SBR tank collection pit will be collected in the separate common sludge sump by pumping. The sludge from the common sludge sump shall be transferred to sludge thickener and to Centrifuge by means of pumping. Poly dosing system shall also be there to enhance the thickening and dewatering process.

The centrate from Centrifuge machine shall be recirculated to receiving chamber at primary treatment location.

The thickened and dewater sludge shall be further transferred to sludge dryer unit to achieve high dry solid content of 80-90 %

The dried sludge shall be stored separately, carefully handled and disposed as per KSPCB norms as class B.

5.12.8 Plant Water System

The entire plant water requirement shall be taken from outlet of CCT and shall be used for multiple applications including but not limited to alum and polymer solution preparation, motive water for chlorination, filter backwash system, thickener dilution water, general cleaning and flushing needs and for landscaping requirements plant water should meet no detectable Fecal Coli form standards. Plant water shall be further treated and shall be used for hot water generation and for using as process water for sludge treatment facilities. The plant water system shall be designed to provide adequate water pressure for all of the above applications.

5.12.9 Chlorination Equipment and Building

A Chlorination Building shall be provided to house all chlorination equipment including chlorine cylinders, chlorinators, and all associated equipment.

5.12.10 Deleted

5.12.11 Deleted

5.13 Design/Sizing Criteria and Other Requirements

5.13.1 STP

The Preliminary Design and Sizing is shown below is indivative only, the bidder needs to work out the detail design to meet the effluent quality requirement as per NGT norms

Design basis - QUANTITY			
Design Average flow, Q	=	25	MLD
	=	25000	m^3/d
	=	1041.67	m^3/hr
	=	0.29	m^3/s
Peak Factor	=	2.25	
Peak flow	=	56.25	MLD
	=	56250	m^3/d
	=	2343.8	m^3/hr
	=	0.65	m^3/s

DESIGN BASIS OF UNIT OPERATIONS			
RECEIVING CHAMBER			
Flow to the inlet chamber	=	2343.75	m^3/hr
	=	0.65	m^3/s
Retention time provided	=	30	s
COARSE SCREEN			
No of coarse Screen (Mechanical)	=	1	No
Design Flow Per Screen Channel	=	2343.75	m^3/hr
Approach Velocity in FSC	=	0.4	m/Sec
Velocity Through Clean Bar Screen at Peak Flow in FSC	=	0.9	m/Sec

Bar Spacing	=	0.01	m
Bar Thickness	=	0.01	m
Angle of inclination of the screen	=	60.00	Deg
WET WELL			
Pumping capacity at peak flow Q	=	2343.75	m^3/h
	=	39.06	m3/min
Time for one pump cycle (in minutes) T	=	15	min
Possible depth below invert of sewer	=	2	m
Raw sewage transfer pump:			
Total pumps	=	3	2W +1 S
Capacity of pump to be pumped peak flow	=	2343.75	m^3/hr
Each Capacity of pump required	=	1171.88	m^3/hr
Each Capacity of pump provided	=	1200	m^3/hr
Pump head provided	=	20.00	MWC
INLET CHAMBER			
Flow to the inlet chamber	=	2343.75	m^3/hr
	=	0.65	m^3/s
Retention time provided	=	30	s

FINE SCREEN				
No of fine Screen (Mechanical)		=	1	No
No of fine Screen (Manual)		=	1	No
Total Peak Flow rate		=	2343.75	m^3/hr
Design Flow Per Screen Channel		=	2343.75	m^3/hr
Approach Velocity in FSC		=	0.4	m/Sec
Velocity Through Clean Bar Screen at Peak Flow in FSC		=	0.9	m/Sec
Minimum Velocity		=	0.3	m/Sec
Bar Spacing		=	0.006	m
Bar Thickness		=	0.01	m
Angle of inclination of the screen		=	60.00	Deg
GRIT CHAMBERS				
No. of Units	**n**	=	2	Nos.
Average flow	**F avg**	=	25000	m^3/day
Peak factor	**pf**	=	2.25	
Design flow (Peak flow) i.e. (F avg x pf)	**Fpf**	=	56250	m^3/day
		=	0.65	m^3/sec
Temp, Ambient	**T**	=	18	Deg.C
Sp.Gravity of grit particles	**Sp.Gr**	=	2.65	
Assumed size of grit particles		=	0.0002	m
Kinematic viscosity at 24 deg.C	**kv**	=	0.000001	Sqm/sec
Settling Velocity	**Vs**	=	0.02	m/Sec
Reynolds Number	**R**	=	2.98	>1

Surface over flow rate	**SOR**	=	1,606.88	m^3/m^2 /day
Settling efficiency as per CPHEEO		=	75	%
Settling basin performance index n=1/8		=	0.13	
Factor Kc for grit		=	4	
Critical Velocity	**Vc**	=	0.20	m/sec
PARSHALL FLUME				
Number of units	n	=	1	Nos.
Average flow	F avg	=	25000	m^3 /day
Peak factor	pf	=	2.25	
Design flow (Peak flow) i.e. (F avg x pf)	Fpf	=	56250	m^3 /day
Throat width of flume	W	=	0.3	m
Sloping convergent length towards throat	A	=	1.35	m
Width at the beginnning of convergent section	D	=	0.831	m
Length of convergent section	B	=	1.322	m
Far and width of divergent section	G	=	0.9	m
Length of divergent section	C	=	0.6	m
K		=	0.075	m
Z, Constant		=	0.225	m
HA Depth of flow in upstream leg of the flume at one third point in m				
HA = (D+Z) / 1.1		=	0.96	m

EQT+ANOXIC TANK (part of equalization with about 45 minutes retention)			
Retention time provided	**=**	8	h
AIR BLOWER FOR EQUALIZATION TANK MIXING			
Mixing air as per CPHEEO	=	1.8 -2.7	m3/hr/m2 of tank area
Mixing rate considered in design	=	2.2	m3/hr/m2 of tank area
ANOXIC MIXER:			
No . Of Tanks	=	1	Nos
Mixing Rate	=	0.6	m3/h/m3 V
S.B.R. TANK SIZING:			
SBR CYCLE TIME MAINTAINED SHOULD BE MINIMUM SPECIFIED HERE, IRRESPECTIVE OF THE DESIGN, CONFIGURATION AND GEOMETRY OF THE SBR SYSTEM			
Filling & Aeration Phase	**=**	2	hr
Settling Phase	**=**	0.5	hr
Decanting Phase	**=**	1.5	hr
Total Cycle Time	**=**	4	hr
No. of Cycles per day/tank	**=**	6	Nos.
MINIMUM FOUR HOURS TO BE PROVIDED FOR EACH CYCLE			
Hours of Aeration Time/day	**=**	12	hr
Design inlet BOD	**=**	360.00	mg/L
MLSS	**=**	4000	mg/L
Conisdering MLVSS= 0.6 X MLSS	**=**	2400	mg/L
F/M	**=**	0.2	
No. of tanks provided	**=**	2 TO 4	Nos.
Number of tanks can be designed based on value engineering. Minimum 2 tanks are required at 2 x 50% flow configuration.			

Hydraulic Retention Time	=	18	Hrs
HRT minimum should be maintained at 12 to 18 hours on normalized flow rate.			
SBR TANKS SUMMARY OF KEY DESIGN SPECIFICATIONS: 1. Cycle time should be minimum of FOUR hours per cycle and can be increased based on individual design and sizing philosophy 2. Minimum of TWO tanks, i.e. 2 x 50% of capacity to be provided. However, based on individual design and sizing philosophy, the number of tanks can be between TWO to FOUR in parallel split inlet flow configuration 3. Hydraulic retention time should be minimum 12 to 18 hours on normalized flow based on individual design and sizing philosophy. 4. IMPORTANT: ALL SBR PROCESS ANCILIARIES i.e. AIR SUPPLY SYSTEM, RAS & SAS PUMPING SYSTEMS, DECANTATION SYSTEMS SHOULD BE DESIGNED AS INDIVIDUAL SYSTEMS FOR EACH TANK. NO COMMON HEADERS ARE RECOMMENDED. For example, if 2 tanks are there, then there must be TWO sets of RAS Pumps i.e. 2 pumps – 1w+ 1 sb for each tank x 2 tanks = 4 pumps in total and the same philosophy is to be adopted for all the other equipment related to the SBR process.			
R.A.S. PUMP SIZING:			
Providing recirculation ratio (of Feed flow per tank) to be considered	=	25	%
SBR BLOWER & DIFFUSER SYSTEM SIZING:			
Theoritical oxygen requirement per kg of BOD	=	1.2	Kg per kg BOD
Practical requirement considered	=	1.40	Kg per kg BOD
Theoretical oxygen requirement per kg of BOD nitrogen	=	4.7	Kgs O2/kg BODn
Practical requirement considered	=	5.0	Kgs O2/kg BODn
Oxygen fraction in air theoretical	=	23.2	%
Oxygen fraction considered	=	23.0	%

APPLYING PROCESS LOSSES:			
Applied SOTE for sewage for EPDM tubular diffusers, 90mm dia x 990mm long		0.2	index
Alpha Fouling Factor - based on waste water characteristics (range is 0.3 to 1.0)		0.9	index
Fouling Factor F - loss in OTE due to fouling potential (normal range is 0.5 to 1.0)		0.9	index
Beta Factor - loss in OTE due to presence of salts and particulates (range is 0.95 to 0.98)		1.0	index
Theta Factor : Variations in OTE due to temperature of waste water		1.1	index
T-factor: fluctuation in oxygen saturation concentration			
(a) oxygen saturation @ 20 deg C		9.1	value
(b) temperature of waste water in bengaluru (average)		18	deg C
(c) oxygen saturation@ 20 deg C		9.0	value
hence T- Factor		1.0	index
Loss in OTE due to all factors together		0.2	index
Applied volume of air under ambient temperature of 25 deg C and at atmospheric pressure		1.3	kgs/m3
aeration time based on cycles / day	=	12.0	hrs/d
AIR BLOWER SIZING CRITERIA: • Each tank to have 1x100% working + 1 x 100% standby OR 2 x 50% working + 1 x 50% standby • Air Blower sizing should confirm to the specifications for air supply as provided above. • Air blower recommended head should be minimum 6 mwc • Alternative air supply systems which are cost effective and / or power savings can be provided with due references and justification on power consumption and benefits. However, the total air supplied should be maintained			
DIFFUSERS:	=		
standard air flow rate / diffuser to be considered for EPDM 90mm dia x 990 mm long	=	8	m3/hr

NOTE ON DIFFUSER SELECTION:

- Alternative to conventional EPDM diffusers can also be provided with due justification and references i.e. BET diffusers
- However, the total air supplied should be greater than or equal to the air supplied required as per blower design and the bubble diameter should be maximum 1 mm i.e. the bubble diameter for EPDM diffusers or BELOW.
- The transfer efficiencies of such alternative diffusers should be minimum confirming to the efficiency considerations for EPDM Tubular or MORE.

S.A.S. PUMP SIZING:			
Excess sludge yield per Kg of BOD	=	0.35	Kg/Kg BOD
Sludge solids consistency	=	0.8	%
Specific gravity of sludge	=	1.05	
Number of Cycles per day per tank	=	6	Nos.

TREATED SEWAGE TANK (decantation product collection tank)			
residence time	=	10	min

TERTIARY TREATMENT – FILTRATION SECTION

Technical specifications of tertiary treatment is provided here.

Filtration step 1 through on-line disc filter / auto wash filter 50 micron rated
Filtration step 2 through glass media based sand filter (specifications and make provided herein)
Filtration step 3 through activated carbon filtration (specifications and make provided herein)

SUMMARY OF 25 MLD SIZING OF GLASS MEDIA FILTER AND ACTIVATED CARBON ADSORPTION :

DISC FILTER / ONLINE AUTO WASH FILTER	Provide 1200m3/ hr Capacity of Disc Filter /Auto wash filter with 50 Micron rating - preferred make: AZUD / ARKAL / AMIAD	Disc Filter	HDPE	1	Nos
Glass Media FIlter	3.0 m Dia X 5.5m Los	Horizontal	MSRL	5	Nos
Activated Carbon Adsorption	3.0 m Dia X 6.1m Los	Horizontal	MSRL	5	Nos
Glass Media	High-calibrated granulometry minimum 0,4 mm. 0,7 mm. on average.	About 95m3 with density of about 2400 kgs/m3; Make: Ms. NATURE WORKS GLASS FILTER MEDIA			
Carbon Media	Iodine value 1100 minimum; Chlorine Halving Value not more than 10 cms	106 m3 with density of about 800 kgs/m3 or LESSER should be provided. PREFERRED MAKES : CALGON / JACOBI / PICO / NORIT only. Local carbon will not be accepted.			
Strainer	Umberlla type K1 Type		PP	10500	nos

SUMMARY OF 50 MLD SIZING OF GLASS MEDIA FILTER AND ACTIVATED CARBON ADSORPTION:

DISC FILTER / ONLINE AUTO WASH FILTER	Provide 2100 m3/ hr Capacity of Disc Filter /Auto wash filter with 50 Micron rating - preferred make: AZUD / ARKAL / AMIAD	Disc Filter	HDPE	1	Nos
Glass Media FIlter	3.0 m Dia X 5.0m LOS	Horizontal	MSRL	10	Nos

Activated Carbon Filter	3.0 m Dia X 5.5m LOS		Horizontal	MSRL	10	Nos
Glass Media	High-calibrated granulometry minimum 0,4 mm. 0,7 mm. on average.	About 180 m3 with density of about 2400 kgs/m3; Make: Make: Ms. NATURE WORKS GLASS FILTER MEDIA				
Carbon Media	Iodine value 1100 minimum; Chlorine Halving Value not more than 10 cms	106 m3 with density of about 800 kgs/m3 or LESSER should be provided. PREFERRED MAKES : CALGON / JACOBI / PICO / NORIT only. Local carbon will not be accepted.				
Strainer	Umberlla type K1 Type			PP	21000	nos

Chlorine contact tank			
HRT	=	30.00	min
Spacing of the baffle	=	7.50	m c/c
Baffle Thickness	=	0.23	m
Baffle Height	=	3.2	m
Baffle Length	=	15	m

CHLORINATION BUILDING				
Chlorine Sizing				
Peak Flow	=	1041.67		m^3/hr
Chlorine Dose	=	5.00		mg/L
Type of Chlorinators	=	Vaccum type		
Required Capacity of Chlorinators	=	521 x 5 / 1000		kg/hr
	=	5.21		kg/hr
No of working Chlorinators	=	1.00		Nos
No of Standby Chlorinator	=	1.00		Nos
Provide cap. Of Chlorinators	=	6.00		kg/hr
Chlorine required per day @ 5mg/L	=	144.00		kg/day
Chlorine required for 30 days	=	4320.00		kg/month
No of 980 kg. Chlorine Tonner provided	=	5.00		Nos
Neutralization tank for Two Cylinders of size 6mx6mx3mx0.5 F.B			1.00	No

Ozone Disinfection System			
Dosing rate as 100%	=	2.00	mg/l
SLUDGE TREATMENT SYSTEM			
SLUDGE SUMP			
Retention time in tank considered	=	6.00	hrs
SAS SLUDGE THICKNER			
Solid loading rate	=	30.00	kg/m^2 /d
Hydraulic loading rate	=	12 to 14	m^3/m^2 /d
SWD	=	4.00	m
SS removal efficiency in Thickener	=	97.00	%
% of solids in Thickener underflow	=	4.00	%
THICKENED SLUDGE SUMP (to collect underflow from thickener)			
Tender Requirements			
Number of units	=	1.0	Nos
Free board	=	0.50	m
Solid concentration	=	4.00	%
No. of sludge withdrawls	=	1.00	No / Shift
Hydraulic retention Time (HRT) of thickened sludge sump provided	=	45.00	min
SUPERNATANT CUM CENTRATE SUMP			
Hydraulic Retention Time (HRT) of Sump provided	=	30	Minutes

CENTRIFUGE BUILDING WITH FEED PUMP HOUSE			
Operating Hours of Sludge Dewatering Machines provided	=	16	hrs/day
	=	7	days/week
	=	112	hrs/week
POLYELECTROLYTE DOSING SYSTEM			
Tender requirements:			
Retention time of PED	=	1	day storage
Total volume of PED tanks (min)	≥	#REF!	m3
Minimum no of PED tank	=	2	Nos.
Solution strength	=	0.005	
Design PE dosage	=	1.5 to 3	Kg/Ton of Dry Solids
Design:			
Design Polyelectrolyte Dosage (Max)	=	1.5	Kg/Ton of Dry Solids
Design Strength of Polyelectrolyte Solution	=	0.005	
DEWATERING UNIT			
Solids recovery in centrifuge	=	95.00	%
Sp. Gravity of sludge	=	1.14	
Density of sludge	=	1140.00	
% of solids in cake per machine	=	25.00	%

ANNEXURE:

Detailed design and sizing of the filtration section is provided herein. It is recommended to follow the design and sizing criteria as given herein. Deviation on specifications, design, sizing to be justified with proper calculations

I: 25 MLD GLASS MEDIA FILTRATION & ACTIVATED CARBON FILTRATION DESIGN & SIZING:			
GLASS MEDIA FILTERS – 25 MLD			
TOTAL FLOW	=	1041.00	m^3/h
TOTAL NUMBER OF FILTERS	=	5	Nos.
WORKING FILTERS	=	4	Nos.
STANDBY FILTERS	=	1	Nos.
TYPE OF FILTER	=	HORIZONTAL	

SERVICE CYCLE	=	24	hrs
DESIGN FLOW PER FILTER	=	260.25	m^3/h/filter
DESIGN VELOCITY DURING SERVICE	=	17	m^3/m^2/hr
DESIGN VELOCITY DURING ONE FILTER UNDER BACKWASH	=	17.0	m^3/m^2/hr
CROSS SECTIONAL AREA OF EACH FILTER	=	260.3/17	m^2
	=	15.3	m^2
DIAMETER CONSIDERED	**=**	**3000**	**mm**
STRAINER PLATE HEIGHT FROM BOTTOM	=	900	mm
GLASS (FINE)			
MEDIA DEPTH	=	1000	mm
QUANTITY PER FILTER	=	18.8	m^3
	=	45120	KG
TOTAL	=	225600	KG
TOTAL MEDIA DEPTH (EXCLUDING SUPPORTING)	=	1000	mm
TOTAL MEDIA VOLUME PROVIDED	=	18.8	m^3
INLET TSS	=	12	mg/l
OUTLET TSS	=	2	mg/l
DIRT LOADING	=	62.46	kg/backwash
VOLUME OF MEDIA REQUIRED BASED ON DIRT LOADING	=	17.8	m^3
MEDIA SURFACE TO CENTRE	=	400	mm
CONSIDERING FREEBOARD OF 50%, HEIGHT REQUIRED	=	1500	mm
RADIUS OF FILTER, R	=	1500	mm
CHORD LENGTH AT MEDIA SURFACE			
	=	2 x √(1500^2 - 400^2)	
	=	2891.4	mm

CALCULATED LOS			
	=	15.3/2.89	m
	=	5292	mm
PROVIDED LOS	**=**	**5300**	**mm**
PROVIDED CROSS SECTIONAL AREA (RECTANGULAR SURFACE)	=	CHORD LENGTH X PROVIDED LOS	
CROSS SECTIONAL AREA (RECTANGULAR SURFACE)	=	2.89 x 5.3	m^2
	=	15.3	m^2
CROSS SECTIONAL AREA (ELLIPSOIDAL SURFACE)	=	(0.19635 x D^2) x 2	
(Ref : PRESSURE VESSEL HANDBOOK BY DENIS MOSS)			
	=	(0.19635 X 3^2) x 2	
	=	3.50	m^2
TOTAL CROSS SECTIONAL AREA FOR HORIZONTAL FILTER	=	18.80	m^2
		OK	
FILTER BACKWASH PUMP			
TOTAL NUMBER OF PUMP PROVIDED	=	3nos – 2 w+1 sb	
CAPACITY OF EACH PUMP REQUIRED	=	282	
EACH PUMP CAPACITY PROVIDED	=	300	m^3/h
RATED CAPACITY OF EACH DMF BACKWASH PUMP	=	300	m^3/h
FILTER AIR SCOUR BLOWER:			
TOTAL NO OF BLOWER PROVIDED	=	2nos – 1 w+1 sb	Nos.
CAPACITY OF EACH BLOWER REQUIRED	=	940	m^3/h
EACH BLOWER CAPACITY CONSIDERED	=	1000	m^3/h
PRESSURE	=	5	mwc
TYPE OF BLOWER	=	LOBE TYPE	

ACTIVATED CARBON FILTERS - 25 MLD			
TOTAL FLOW	=	1041.00	m^3/h
TOTAL NUMBER OF FILTERS	=	5	Nos.
WORKING FILTERS	=	4	Nos.
STANDBY FILTERS	=	1	Nos.
TYPE OF FILTER	=	HORIZONTAL	
SERVICE CYCLE	=	24	hrs
DESIGN FLOW PER FILTER	=	260.25	$m^3/h/filter$
DESIGN VELOCITY DURING SERVICE	=	15	$m^3/m^2/hr$
DESIGN VELOCITY DURING ONE FILTER UNDER BACKWASH	=	15.0	$m^3/m^2/hr$
CROSS SECTIONAL AREA OF EACH FILTER	=	260.3/15	m^2
	=	17.4	m^2
DIAMETER CONSIDERED	**=**	**3000**	**mm**

STRAINER PLATE HEIGHT FROM BOTTOM	=	900	mm
CARBON (FINE)			
MEDIA DEPTH	=	1000	mm
QUANTITY	=	21.1	m^3
		16880	KG
		84400	KG
TOTAL MEDIA DEPTH (EXCLUDING SUPPORTING)	=	1000	mm
TOTAL MEDIA VOLUME PROVIDED	=	21.1	m^3
MEDIA SURFACE TO CENTRE			
CONSIDERING FREEBOARD OF 50%, HEIGHT REQUIRED	=	1500	mm
RADIUS OF FILTER, R	=	1500	mm
CHORD LENGTH AT MEDIA SURFACE			
	=	2 x √(1500^2 - 400^2)	
	=	2891.4	mm
CALCULATED LOS			
	=	17.4/2.89	m
	=	6018	mm
PROVIDED LOS	**=**	**6100**	**mm**
PROVIDED CROSS SECTIONAL AREA (RECTANGULAR SURFACE)	=	CHORD LENGTH X PROVIDED LOS	
CROSS SECTIONAL AREA (RECTANGULAR SURFACE)	=	2.89 x 6.1	m^2
	=	17.6	m^2
CROSS SECTIONAL AREA (ELLIPSOIDAL SURFACE)	=	(0.19635 x D^2) x 2	
(Ref : PRESSURE VESSEL HANDBOOK BY DENIS MOSS)			
	=	(0.19635 X 3^2) x 2	
	=	3.50	m^2
TOTAL CROSS SECTIONAL AREA FOR HORIZONTAL FILTER	=	21.10	m^2

II: 50 MLD GLASS MEDIA FILTRATION & ACTIVATED CARBON FILTRATION DESIGN & SIZING:

GLASS MEDIA FILTERS 50 MLD		
TOTAL FLOW	2083.33	m^3/h
TOTAL NUMBER OF FILTERS	10	Nos.
WORKING FILTERS	9	Nos.
STANDBY FILTERS	1	Nos.
TYPE OF FILTER	HORIZONTAL	
SERVICE CYCLE	24	hrs
DESIGN FLOW PER FILTER	231.4814815	$m^3/h/filter$
DESIGN VELOCITY DURING SERVICE	17	$m^3/m^2/hr$

DESIGN VELOCITY DURING ONE FILTER UNDER BACKWASH	17.0	$m^3/m^2/hr$
CROSS SECTIONAL AREA OF EACH FILTER	231.5/17	m^2
	13.6	m^2
DIAMETER CONSIDERED	**3000**	**mm**
STRAINER PLATE HEIGHT FROM BOTTOM	900	mm
GLASS (FINE)		
MEDIA DEPTH	1000	mm
QUANTITY PER FILTER	18	m^3
	43200	KG
TOTAL	432000	KG
TOTAL MEDIA DEPTH (EXCLUDING SUPPORTING)	1000	mm
TOTAL MEDIA VOLUME PROVIDED	18	m^3
INLET TSS	12	mg/l
OUTLET TSS	2	mg/l
DIRT LOADING	55.556	kg/backwash
DESIGN DIRT LOADING - COMBINED FOR ANTHRACITE AND SAND	3.5	$Kg/m^3/day$
VOLUME OF MEDIA REQUIRED BASED ON DIRT LOADING	15.9	m^3
MEDIA SURFACE TO CENTRE	400	mm
CONSIDERING FREEBOARD OF 50%, HEIGHT REQUIRED	1500	mm
RADIUS OF FILTER, R	1500	mm
CHORD LENGTH AT MEDIA SURFACE		
	2 x √(1500^2 - 400^2)	

	2891.4	mm
CALCULATED LOS		
	13.6/2.89	m
	4704	mm
PROVIDED LOS	**5000**	**mm**
PROVIDED CROSS SECTIONAL AREA (RECTANGULAR SURFACE)	CHORD LENGTH X PROVIDED LOS	
CROSS SECTIONAL AREA (RECTANGULAR SURFACE)	2.89 x 5	m^2
	14.5	m^2
CROSS SECTIONAL AREA (ELLIPSOIDAL SURFACE)	(0.19635 x D^2) x 2	
(Ref : PRESSURE VESSEL HANDBOOK BY DENIS MOSS)		
	(0.19635 X 3^2) x 2	
	3.50	m^2
TOTAL CROSS SECTIONAL AREA FOR HORIZONTAL FILTER	18.00	m^2
	OK	
FILTER BACKWASH PUMP		
TOTAL NUMBER OF PUMP PROVIDED	3	Nos.
NUMBER OF WORKING PUMPS	2	Nos.
NUMBER OF STANDBY PUMPS	1	Nos.
CAPACITY OF EACH PUMP REQUIRED	270	m^3/h
EACH PUMP CAPACITY PROVIDED	300	m^3/h
RATED CAPACITY OF EACH DMF BACKWASH PUMP	300	m^3/h
FILTER AIR SCOUR BLOWER:		
TOTAL NO OF BLOWER PROVIDED	2	Nos.
NO. OF BLOWERS WORKING	1	Nos.
NO. OF BLOWERS STANDBY	1	Nos.
CAPACITY OF EACH BLOWER REQUIRED	900	m^3/h
EACH BLOWER CAPACITY CONSIDERED	1000	m^3/h
PRESSURE	5	mwc
TYPE OF BLOWER	LOBE TYPE	

ACTIVATED CARBON FILTERS 50 MLD			
TOTAL FLOW	=	2083.33	m^3/h
TOTAL NUMBER OF FILTERS	=	10	Nos.
WORKING FILTERS	=	9	Nos.
STANDBY FILTERS	=	1	Nos.
TYPE OF FILTER	=	HORIZONTAL	
SERVICE CYCLE	=	24	hrs

DESIGN FLOW PER FILTER	=	231.48148	m^3/h/filter
DESIGN VELOCITY DURING SERVICE	=	15	m^3/m^2/hr
DESIGN VELOCITY DURING ONE FILTER UNDER BACKWASH	=	15.0	m^3/m^2/hr
CROSS SECTIONAL AREA OF EACH FILTER	=	231.5/15	m^2
	=	15.4	m^2
DIAMETER CONSIDERED	**=**	**3000**	**mm**
STRAINER PLATE HEIGHT FROM BOTTOM	=	900	mm
CARBON (FINE)			
MEDIA DEPTH	=	1000	mm
QUANTITY	=	19.4	m^3
		15520	KG
		155200	KG
TOTAL MEDIA DEPTH (EXCLUDING SUPPORTING)	=	1000	mm
TOTAL MEDIA VOLUME PROVIDED	=	19.4	m^3
RADIUS OF FILTER, R	=	1500	mm
CHORD LENGTH AT MEDIA SURFACE			
	=	2 x √(1500^2 - 400^2)	
	=	2891.4	mm
CALCULATED LOS			
	=	15.4/2.89	m
	=	5326	mm
PROVIDED LOS	**=**	**5500**	**mm**
PROVIDED CROSS SECTIONAL AREA (RECTANGULAR SURFACE)	=	CHORD LENGTH X PROVIDED LOS	
CROSS SECTIONAL AREA (RECTANGULAR SURFACE)	=	2.89 x 5.5	m^2
	=	15.9	m^2

CROSS SECTIONAL AREA (ELLIPSOIDAL SURFACE)	=	(0.19635 x D^2) x 2	
(Ref : PRESSURE VESSEL HANDBOOK BY DENIS MOSS)			
	=	(0.19635 X 3^2) x 2	
	=	3.50	m^2
TOTAL CROSS SECTIONAL AREA FOR HORIZONTAL FILTER	=	19.40	m^2

5.13.1 SPS

The Prelimanry Design and Sizing is shown below is indivative only, the bidder needs to work out the detail design to meet the CPHEEO norms

Wet Well (to be designed As mentioned)

The wet well is to be designed and pumped to the proposed SPS. Sewage will enter into wet well of the pumping station after screening. The wet well shall be circular in shape and shall be designed for an average flow. The capacity of the wet well should be kept such that the detention time in the wet well shall be minimum 15 minutes of average flow and the maximum detention time shall not exceed 30 minutes at average flow. Following criteria's shall be considered to size the sump:

(i) That the pump of the minimum duty/ capacity would run for at least 5 minutes considering no inflow or
(ii) The capacity of the sump is to be so kept that with any combination of inflow and pumping the operating cycle for any pump will not be less than 5 minutes and
(iii) The arrangement of the submersible pumps as per pump manufacturer's data i.e. spacing between pumps, minimum space between pump and wall etc.
(iv) The side water depth (live liquid depth) shall be minimum 2 meter. In addition to the above liquid depth an additional depression shall be provided to ensure adequate submergence of the pump as per the manufactures recommendations. Pumping station should have a room adequate for installing electrical panels. Suitable arrangement should be provided for lifting of pumps.
(v) The diameter to be kept suitable to accommodate the number of pumps required for operation and easy maneuverability of pumps.

The wet well shall be in RCC of minimum M30 grade with sulphate resistant cement in accordance with IS: 3370 and IS: 4111 (part 4). The surfaces of concrete shall be of form work finish with smooth rendering. The chamber shall be provided with PVC encapsulated foot rests as specified in side faces of wall to provide access.

- **Pump House (to be designed to accommodate the pumps, capable of pumping for peak flow)**

The Pump House shall be designed in order to house the pump sets capable of pumping peak flow generated (average flow is 5 MLD). The pump house shall be a RCC framed structure may be located over the wet well designed conforming to IS 456 and other relevant codes. The floor, columns, beams and roof of the pump house shall be in RCC grade minimum M30 while its walls shall be in minimum 230 mm thick brick masonry structure. The building shall be provided with plinth protection as per specification.

The pump house shall be designed with adequate space to accommodate electrical Control Panels for the pumps and coarse screens. A suitably designed with chain pulley block of minimum capacity of 3 times the

maximum single unit weight that may be required to be handled shall be provided with horizontal travel. The height of top of bracket from the floor shall be a minimum of 5 m and the height from floor to soffit of roof 1 beam shall be minimum 6 m.

RCC roof shall be provided for the pump house. The roof shall project 600 mm from the wall of the pump house. Roof shall be provided with water proof coating and PVC/CI rain water pipes as per specifications.

The pump house shall have one manually operated rolling shutter of suitable size at one side wall. The size of canopy shall be minimum 1.0 m wide for the rolling shutter at side. 2 coats of painting with primer coat over rolling shutters shall be provided as per specifications.

The pump house shall be designed for natural lighting and ventilation as per NBC norms. The area of windows and ventilators shall not be less than 20% of the floor area of the pump house.

In addition there shall be adequate electrical lighting arrangement for internal illumination conforming to NBC norms. Further there shall be adequate number of fire extinguishers as per firefighting norms, first aid box, electrical shock treatment chart, electrical shock resistant hand gloves and rubber mates, emergency lamp and tool kit in the pump house.

- **Pumping Machinery**

The Pumping machinery in the pump house shall be designed to handle the peak flow, average flow as well as the lean flow for SBR. For SBR, There shall be minimum 5 submersible pumps (3 working + 2 standby) each designed for minimum 50 LPS against required head, whereas first pump will work for lean flow, First and second pump combination for average flow and first, second & third pump in combination will work for peak flow. The pumps shall be Submersible raw sewage pumps with centrifugal, non-clog type design. The impeller should be of a non-clog design with smooth passage and solid handling capability of 100 mm size. The pumps shall have cutting edges facing the impeller to share the floating and suspended clogging materials like fibres, plastics, etc. The impeller shall be of CF-8M with SS-410 shaft. The pumps will have automatic coupling arrangement at discharge end for removal and a guide pipe and chain in SS 304 will be provided for removal and lowering of pumps. Pump shall run smooth without undue noise and vibration. Noise level shall be limited to 85db at 1.86m. Vibration shall be limited as per BS 4675 Part I.

Bearing shall be easily accessible for inspection and maintenance. The bearings shall be having a minimum life of 25000 hours of working.

The motor shall be CI squirrel cage type suitable for 415 V, 3 phase, 50 Hz supply continuous duty with class 'F' insulation and IP 68 Protection. Motor shall have integral cable parts and the cable entries shall be sealed. The cables shall be leak tight with respect to liquids and firmly attached to the terminal block. The Motor shall be designed for non-overloading characteristic of quantity.

The critical speed of the rotor shall be at least 30% above the operating speed. Complete rotor shall be balanced dynamically. The moisture sensor of the tripping unit shall be located inside the oil chamber.

Level switch for automation and alarm in the pumps for tripping off at low level and high level shall be provided.

In each pumps suitable diameter electrically operated sluice valve and dual plate check valves shall be provided with relevant IS /BS standards

In the common hear one number of electrically operated sluice valve and dual plate check valve shall be provided with relevant IS /BS standards with necessary RCC valve chambers.

- **Pump Performance**

All pressure parts of the pumps shall be subjected to hydrostatic tests prior to assembly to the satisfaction of the Engineer at 1.5 times the maximum working pressure, obtained with the delivery valve closed and suction pressure at twice the working pressure whichever is higher for a duration of 10 minutes. The Impeller and pump rotating assembly shall be dynamically balanced. Each pump shall be subjected to performance tests for full operating range individually to BS: 5316: Part 2. Test shall be carried out for performance at rated speed with minimum NPSH as available at site. Pump performance shall be within the tolerance limits specified in BS: 5316: Part 2.

Note: Contractor shall install and monitor, at the inlet and outlet of the sewage treatment plant, online monitoring devices to monitor the consented parameters mentioned in the table above. Data / Analysis results shall be sent to Bangalore Water Supply and Sewerage Board (BWSSB) - Data Monitoring Cell

End of Part 5

PART 9

GENERAL PAINTING AND PROTECTION REQUIREMENTS

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PART 9

GENERAL PAINTING AND PROTECTION REQUIREMENTS

9.1 General

The preparation, application and conditions for work shall comply with the recommendations of BS 5493 and BS 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions.

Paints, primers and undercoats shall be obtained from the same manufacturer and except where a definite time is specified between mixing and application, shall be ready mixed for use. They shall be compatible with one another.

Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc. and shall carry a label giving details of quality and instructions for use.

No site painting shall be carried out unless the surface to be painted is dry, the air temperature above 4oC and the relative humidity less than 85%.

Surfaces shall be prepared for painting in accordance with these specifications and the paint manufacturer's written recommendations. Surfaces shall be clean of dirt, oil, grease or other deleterious substance. Painting shall not commence until surface preparation has been inspected and approved by the Engineer.

Test plates carrying finishes from the actual coating used may be required by the Engineer for inspection and test purposes.

To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white.
Priming to two mating surfaces shall be applied prior to assembly.

All items of Plant and equipment shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site, of sufficient thickness to produce a uniform colour and appearance. Such painting shall be carried out within one month of successful acceptance trials for the Plant.

All paint thicknesses shall be checked using an alkometer or equivalent instrument, supplied by the Contractor, for each layer of paint, to the reasonable satisfaction of the Engineer.

9.2 Colour Coding and Labelling of Pipes and Equipment

All pipes and equipment shall be colour coded to a schedule to be agreed with the Engineer before any site painting starts, or earlier if necessary to suit manufacturing procedures. Contractor shall prepare the schedule at the appropriate time and submit to Engineer with reasonable time allowed for comment and approval. Valves and fittings shall be painted in the same colour as the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment the pipe colour shall extend up to but not including the flange attached to the equipment.

All pipelines shall be identified by painted-on labels or stick-on 90 micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Stick-on labels shall have an effective service life of not less than 10 years. In the case of stick-on labels, letters of titles shall be pre-spaced on carrier tape and the complete title protected by one piece removable liners. Titles shall be at intervals not less than 8 m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Engineer. Lettering sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe.

Pipes smaller than 22 mm outside diameter shall be labelled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel.

Titles shall also be provided on all equipment in locations and in sizes to be approved by the Engineer.

9.3 Cleaning and Preparing at Place of Manufacture

The Contractor shall be responsible for the cleaning and preparation for painting, priming or otherwise protecting as specified of all parts of the Plant and equipment at the place of manufacture prior to packing.

(a) Cleaning

Parts shall be cleaned prior to testing at the manufacturer's works. Parts subject to hydraulic test shall be tested before any surface treatment. After testing all surfaces shall be thoroughly cleaned and dried out, if necessary by washing with an approved dewatering fluid, prior to surface treatment.

(b) Preparation

Bright parts: Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by the Engineer, before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

Embedded parts: Embedded parts or those parts of an assembly which will be embedded in concrete shall be thoroughly descaled and cleaned to the satisfaction of the Engineer and before being packed shall be protected by a cement wash or other approved method. No cast iron or steel work shall be bitumen or tar coated where it is to be cast into the concrete and provision shall be made for cleaning off any portions so coated.

Grit or shot blasted parts: Grit or shot blasting shall be carried out in accordance with B.S. 7079 to a standard between `First Quality' and `Second Quality' given in Table 1 after which the maximum amplitude of the surface shall not exceed 0.1 mm.

Cast Iron and Steel pipework: All ungalvanised steel pipework including pump pipework, bearing spiders and tunnel tubes shall be prepared internally and externally by grit or shot blasting as specified above and the surfaces primed as specified within four hours of blasting.

9.4 Painting and Finishing at Place of Manufacture

This Clause governs the methods for the protective coatings to be applied to structural steel, metalwork and ironwork as corrosion protection systems. The systems designed as specified here shall be applied as specified under Protective Coatings. In case of conflict, protective coatings specified elsewhere for particular works such as pipes and cladding shall take precedence over any conflicting requirements specified herein. This specification makes reference to the following standard:

B.S.5493 "code of practice for the protective coating of iron and steel against corrosion"

The Contractor shall design each protective coating system and shall submit details of each system to the Engineer for approval. Submissions shall be in the format of the examples given Clause 9.5 with such additional information and samples as the Engineer may require enabling the system to be assessed.

Protective coatings shall be designed in accordance with B.S. 5493 to have a long life, generally of at least 10 years to first maintenance. Protection systems shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary using single part paints.

For the purposes of system design the general environment shall be as specified in B.S. 5493 Table 3 Part 2 `Exterior exposed polluted inland'. Bulkhead gates and stop logs shall be assumed to be exposed to a Table 3 Part 8 `Non-saline water' environment unless otherwise approved by the Engineer.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coating of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final finish coat of aesthetically pleasing appearance of a colour and type as approved by the Engineer.

Protective coating systems shall generally fall into one of the following basic systems:

- Galvanising;
- Galvanising plus painting;
- Multi-coat painting;
- Bitumen enamel;
- Others as proposed by the Contractor and approved by the Engineer.

The Contractor shall submit to the Engineer details of his proposals for the corrosion protection (generally falling into the above categories) of each of the items listed below and any other items requiring such protection:

- trash screens, flooring, ladders, access covers and frames, step irons and other components which are inaccessible but subject to abrasion/damage;
- structural steelwork (including crane beams, monorails, crane structures and chassis), bulkhead gates, stop logs, grappling beams, steel tanks and other large items readily accessible for maintenance;
- valves and other corrosion-susceptible items which may be buried and are not covered by the provisions of other specifications :
- other components not covered by the above for which the contractor may propose a system which he considers to be more suitable for the duty;
- Electrical switchgear, transformers, control panels etc.
- Equipment, piping and miscellaneous metals.

All painting material shall be applied in strict accordance with the paint manufacturer's instructions.

(a) Plant supplied to site with final coating applied:

Cubicles, cabinets etc. other than those specified in Part 4 Section J

Before any steel work is painted the steel must be thoroughly cleaned and an approved anti-rusting priming coat applied so that the possibility of rusting or corrosion taking place is negligible. All surfaces should have not less than two stoved undercoats and two top coats or air drying paint. The undercoats shall be easily distinguishable in shade or colour form the priming and finishing coats. The two final coats shall be in a colour and finish to be advised by the Engineer. The inside surfaces of any cubicles, cabinets etc. where condensation is liable to occur, shall be coated with an approved anti-condensation composition. The Contractor shall ensure that all component sections of a switch board wherever manufactured shall have a finish of uniform texture and an exact colour match.

Chromium plated parts: Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of B.S. 1224 including the following provisions. No blistering of any surfaces will be tolerated. The finished appearance shall be bright. Where the base metal is steel, plating shall be applied in accordance with Table 2. Other base metals shall be plated in accordance with Tables 3, 4, 5 as appropriate. For all base metals the service condition number 2 shall be used.

Small bore pipes, valves and fittings etc., which are sited in architecturally finished areas and selected by the Engineer shall be chromium plated. Any damage to chromium plating shall be repaired before transfer of the facility to Owner.

Galvanised parts: All materials to be galvanised shall be of the full dimensions shown on the approved drawings or specifications and all welding, bending, punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process begins. Parts to be galvanised shall be shot blasted as specified above. Such parts shall be galvanised not more than four hours after commencement of shot blasting. Any Site modification of galvanized parts shall be covered well by zinc rich primer and aluminium paint.

Wherever galvanizing has been specified the hot dip process shall be used. The galvanized coating shall be of uniform thickness. Weight of zinc coatings for various applications shall not be less than those indicated below:

Fabricated steel	
Thickness less than 2 mm but not less than 1.2 mm	340 g/m^2
Thickness 2 mm and above	460 g/m^2
Fasteners	
Up to nominal size M10	270 g/m^2
Over M10	300 g/m^2

Galvanizing of material shall be carried out in accordance with the latest editions including all official amendments and revisions of IS 2629, 2633, 4759 and 6745.

All galvanising shall be done by the hot dip-process. No alternative process may be used without the approval of the Engineer. No components shall be galvanised which are likely to come into subsequent contact with oil.
The zinc coating shall be uniform, clean, smooth and free from spangle. In the case of component parts the zinc coating shall weigh not less that 610 g/m2 of area covered and shall not be less than 0.090 mm in thickness.

Bolts and nuts shall be sherardised. The Engineer may select for test as many components to be weighed after pickling, and before and after galvanizing as he may think fit.

All galvanised parts shall be protected from injury to the zinc coating due to differential serration and abrasion during periods of transit, storage and erection. Damaged areas of the coating shall be touched up with an approved zinc-dust paint or other approved flake metallic compound.

Cast iron and steel pipework: (Internal surfaces)

The internal surfaces shall have an approved coating.

Where a bitumen based coating is used, it shall be in accordance with Type 2 of B.S. 4147.

Prior to lining, the pipe shall be grit blasted and primed with an approved primer. The lining shall be in accordance with B.S. 534. After installation, the internal lining shall be made good and satisfactorily tested with a Holiday detector to 8 KV.

The coating shall be suitable for use in contact with the respective process fluids. The type of coating shall be entered in Schedule L provided and the Engineer reserves the right to call for test plates of the paint. The manufacturer shall at the time of ordering carry out the `Taste and smell test' (Appendix E of B.S.4147) and `Effects on water test' (Appendix C of B.S. 3416) and forward 3 copies of the test results to the Engineer for approval.

Where pipes are to be welded after the protective coatings have been applied the pipe surfaces shall be primed and all other coating stopped 250 mm short of the weld preparation. Collars and fillings shall be primed but no other coating applied.

The manufacturer shall supply a sufficient quantity of suitable materials to repair damage occurring during delivery to site and to provide a flush finished internal lining at welded joints. Sufficient coating shall be supplied to fill in the recesses at internal welds over the previously primed areas. The costs of these materials shall be included in the unit rates for the supply of the pipes and specials.

The coating shall be applied in accordance with the manufacturer's instructions and with Appendices J and K of B.S. 3416.

Machinery- (Internal surfaces) e.g. pumps, valves, strainers, rising and suspension mains of wet well pumps:
As for cast iron and steel pipe work (Internal surfaces).

Cast iron and steel parts (External surfaces) immersed in Water:

All ungalvanised metal parts which will be immersed in water shall be cleaned by grit blasting and within four hours of blasting given a coating similar to that specified for internal surfaces.

Cast iron and steel (External surfaces) in manholes and areas of high humidity.

Ungalvanised metal parts exposed in manholes or areas of high humidity shall be cleaned by grit blasting and given two coats of a black bituminous solution.

(b) Plant forwarded to site for final finishing.

Cast iron and steel parts (External surfaces) outside buildings:

All ungalvanised metal parts which will be exposed to the outside atmosphere shall be cleaned by grit blasting and provided with two coats of an approved primer.

Cast iron and steel parts inside buildings:

All exposed metal surfaces which will not be immersed in water or exposed in areas described above shall be rubbed down, cleaned by grit blasting and within four hours of blasting given one coat of an approved primer before packing.

Painting of Valves

a. Prior to Inspection
   i. Surface Preparation: Sand Blasting to SA 2 $^{1}/_{2}$ Grade – Near white blast cleaning.
   ii. Application of Primer Coating after blast cleaning

b. Post Inspection

i. Application of Intermediate Coat:
One coat of two component high build polyamide crude re-coatable epoxy coating to achieve DFT 150 micron.

ii. Application of Finish Coat:

One coat of two component aliphatic polyurethane finish to achieve DFT 80 micron.

9.5 Painting at Site

Immediately on arrival at the site, all items of plant shall be examined for damage to the paint coat applied at the manufacturer's works, and any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint.

Steel and cast iron parts received at site shall be provided with adequate number of further coats of coal tar epoxy polyamine coating to a total dry film thickness of 275 microns including the primer coats. All sharp edges, nuts, bolts and other items difficult to be painted shall receive a brush coat of specified paint before application of each coat of epoxy based coal tar paint giving a total dry film thickness of at least 275 microns. In the case of fabricated steelwork this work shall be done after assembly.

Before painting is commenced the Contractor shall submit for the approval of the Engineer, full details of the paints he proposes to use together with colour charts for the gloss finishes.

After erection, such items which are not finish painted shall be finish painted, items finish painted at the Manufacturer's works shall be touched up for any damaged paint work.

The painting work shall conform to the following requirements:

(a) The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005
(b) After surface preparation, two coats of primer-red oxide zinc chromate with modified phenolic alkyd base conforming to IS: 2074 shall be applied. Dry film thickness of each coat shall be 25 microns.
(c) For finish painting, after application of primer as in (b) above, two coats of synthetic enamel conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be 25 microns.
(d) Colours shall be selected as per IS: 5

No painting shall be carried out unless the item has been inspected and accepted by Engineers at the Manufacturer's works

The dry paint film thickness shall be measured by Electrometer or other instruments approved by the Employer. In order to obtain the dry film thickness DFT specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm^2. Painted fabricated steel Work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no poles of water or dirt can

accumulate on the surface. Suitable packings shall be laid between the stacked Materials. Where cover is provided, it shall be ventilated.

The painting procedure shall be submitted in the following format:

(a) Surface Preparation
(b) Reference Standard
(c) Conditions of Work
(d) Type of Materials
(e) Tests and inspection methods and sequence, thickness (DFT)
(f) Colour in final coat
(g) Total thickness of coats (DFT)
(h) Other necessary data and information

The following items in the plant are required to be painted;

(a) Outer surfaces of pumps, valves, pipes, fittings, motors etc., not exposed to treated water
(b) Steelwork exposed to weather, such as outer surface of surge vessel, valves, pipes etc.
(c) Internal Plant and pipework, cranes, exhaust fans, fire extinguishers and miscellaneous steelwork not exposed to weather
(d) Steelwork exposed to weather, such as platforms, ladders, handrailing, etc.
(e) Steelwork exposed to humid weather and requiring hard maintenance and repairs
(f) Buried steelwork
(g) Buried pipes and fittings prior to application of wrapping
(h) Other equipment, as per requirement of employer.

All buried steel pipes and fittings shall be coated and wrapped with hot or cold applied, self-adhesive, polyethylene in accordance with AWWA C214 or equivalent Standard.

Cast iron or mild steel parts to be built into concrete shall remain unpainted. Immediately before it is cast in-situ, it shall be made perfectly free from dirt, scale, loose rust, paint, oil limewash or any other coating.

No blast cleaning or painting shall be applied to corrosion resistant Materials such as stainless steels, Ni-resist cast iron, bronze and other metals used for seals, bearings, lighting fitting etc.

Machined surfaces such as gear teeth shall be coated with a thick layer of grease. Other mechanical surfaces such as shaft ends or other bright parts shall be coated with two coats of an anti-rust solution which can be removed easily when required. Permanently bolted mechanical interfaces such as flanges shall be coated with a thin coat of anti-rust compound before assembly.

All primers, under coats and finishes shall be applied by brush or airless spray, except where otherwise specified.

Consecutive coats shall be in distinct but appropriate shades. All paints shall be supplied from the store to the painters, ready for application, and addition of thinners or any other Material shall be prohibited. Any instruction given by the paint manufacturer shall be strictly followed.

All painting shall be carried out by the painters under supervision. Paint shall be applied to the dry surface which has been prepared in compliance with the approved procedure.

Paint shall not be supplied or applied when the ambient temperature falls below $4^{o}C$ or relative humidity rises above 85%.

The Plant and equipment shall be inspected and reviewed at the various stages of the coating application both at the manufacturer's Works and at the Site of the Works. Samples may be taken from the paints as delivered and submitted to such tests as are deemed necessary. The completed paint

systems shall be tested by instruments to ensure that the protection is of adequate thickness and is free from pinholes and the direct measurement of adhesion shall be checked by the removal of a small section of the coating. The Contractor shall supply all instruments and apparatus required for carrying out such tests required by the Employer.

9.6 Waterworks Finish

A high standard of finish, defined as "Waterworks finish" is required for all Plant as detailed below.

9.6.1 Welding and flame cutting

A smooth neat finish, by careful grinding if necessary is required on all exterior welding and flame cutting. All plates and bars used in fabrication shall have smooth surfaces with no pitting or deep slag inclusions

9.6.2 Castings

Casting surfaces shall be smooth and free from surface blowholes. Stock castings shall be specially selected with this in mind.

All castings shall be shot blasted before machining.

9.6.3 Covers

All covers shall be firmly fixed. Weldmesh shall sit square in its frame. Where panels are placed next to each other the patterns shall line up.

9.6.4 Flanges and beadings

All bolt holes shall be spot faced parallel with the mating face for good seating of nuts and bolt heads. Surplus jointing shall be removed from mating faces and peripheries.

9.6.5 Items to be chromium plated

Name plates, instruction plates, rotation arrows, indicators and pointers, small bore pipe work, tundish oil level gauges and fittings, small valves (including air valves), plugs and grease nipples, which are sited in architecturally finished areas and as selected by the Engineer, shall be chromium plated. Damage to chromium plating shall be made good.

All pipes, fittings and appurtenances, shall be fitted in a straight, neat symmetrical manner so as to present a pleasing appearance.

9.6.6 External screws, bolt heads, nuts and washers

These shall be chromium plated sherardised or shall be of stainless steel.

9.6.7 Gauges

All indicating gauges fitted to any machine assembly shall be of similar appearance and grouped together to present a pleasing aspect. They shall all have chromium plated cases, bezels, cocks and fittings.

End of Part 9

PART-10B

PARTICULAR CIVIL & STRUCTURAL REQUIREMENTS

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PART 10 B

PARTICULAR CIVIL & STRUCTURAL REQUIREMENTS

Technical Specifications

10.1 Design Submissions

Before proceeding with design and drawing preparation the Contractor shall submit detailed general philosophy of design (Design Basis Report) of various parts of (all) the structures and equipment foundations along with explanatory sketches for review. Only after the review and incorporation of comments on the general philosophy, as offered during the review, the Contractor shall submit any design document and/or drawing for review and approval for construction.Cnotractor make neccessery arrangments and get design and drawings approved by IISc, Bengaluru without any addational cost to BDA

10.1.1 Design Philosophy

Following are the details which are to be included in the general design philosophy document submission:

1. Design assumptions/philosophy for Liquid Retaining Structures with various boundary conditions as applicable
2. Design assumptions/philosophy for buildings
3. Design assumptions/philosophy for all other structures
4. Standard General Notes shall include material properties (grade, strength, unit weight etc.), development lengths, lap/splice lengths, Anchorage lengths under tension and compression, clear cover, water proofing specifications, legend used etc.

10.1.2 Standard Details

Following typical details shall also be submitted for approval prior to proceeding with detailed design:

1. Reinforcement detail showing the development length at Column/Footing intersection, Column and Roof beam intersections, Walls and Base slab intersections; Walls and cover slab intersections
2. Detailing of the reinforcement for columns, beams, beam/column intersection, footing/column intersection, and Slabs as per relevant code provisions/requirements depending upon the assumptions made in the design as applicable.
3. Reinforcement detail for cut-outs in slabs and walls with maximum size of cut-outs
4. Reinforcement detail at top of RCC trench walls showing edge/seating angles
5. Pouring sequence of concrete and standard details for construction joints, expansion joints, contraction joints, etc.
6. Details of Manholes and Rungs to be placed in the tanks
7. Detail for rain water drainage down takes at terrace slab and water proofing at roof/sunken slabs
8. Detail for storm water drain, plinth protection and entrance ramps to buildings
9. Detail for Handrails and fixing detail of handrail to concrete, Steel Ladders and fixing detail of ladders to Walls/Concrete, Cage ladders, Boundary walls, Fencing and Gates, etc.,
10. Material Specifications and application methodology for Anti-Corrosive Internal Coating/Lining protection of Concrete Surfaces

Contractor shall not submit the detailed design and drawings until items mentioned in under clauses 10.1.1 and 10.1.2 are approved.

Complete detailed design calculations of foundations and superstructure together with general arrangement drawings and explanatory sketches shall be submitted by the Contractor to the Engineer.

Separate design calculations for foundations or superstructures submitted independent of each other shall be deemed to be incomplete and will not be accepted by the Engineer.

Submissions of detailed design calculations and Good for Construction drawings shall include the following as a minimum:

A. Detailed Design Calculations
   1. One (1) Copy of a Compact Disc (CD) containing electronic files relevant to the structure"s modelling, analysis and design calculations (Microsoft Excel, Staad Pro, etc.). Files submitted shall be in editable format.
   2. Print copy (6 Copies) of the contents as submitted in the Compact Disc.

B. Good for Construction Drawings
   1. One (1) Copy of a Compact Disc (CD) containing Autocad files (Civil General Arrangement, Structural Dimensions and Reinforcement Details) pertaining to the structure. Files submitted shall be in editable format.
   2. Print copy (6 Copies) of the contents as submitted in the Compact Disc. Prints to be submitted on A1 Size Sheet as a minimum or A0 Size Sheet when required by the employer.
   3. Bar-bending schedule indicating the number, shape and size of the rebars shall be submitted as part of the Reinforcement Details
   4. Detailed drawing showing the location, number and depth of inserts shall be included for any structural steel inserts/Metal inserts in the structure such as rungs, bolted connections for ladders/railings, etc.
   5. Location of Construction Joints and pour sequence shall be included on the drawing for base slabs, walls and top slabs.
   6. Revised drawings shall be submitted by clouding at the location with the latest revision number and also show the history of revisions in a table format just above the title block.

The design considerations described hereunder establish the minimum basic requirements of plain and reinforced concrete structures, masonry structures and structural steel works. However, any particular structure shall be designed for the satisfactory performance of the functions for which the same is being constructed. The Contractor shall also take care to check the stability of partly completed structures.

10.2 Design Standards

All the designs shall be based on the latest Bureau of Indian Standard (BIS) Specifications or Codes of Practice. The design standards adopted shall follow the best modern engineering practice in the field based on any other International Standard or specialist literature subject to such standard reference or extract of such literature in the English language being supplied to and approved by the Engineer. In case of any variation or contradiction between the provisions of the BIS Standards or Codes and the specifications given along with the tender document, the provision given in this Specification shall be followed.

All **Reinforced Concrete** structural design/details shall conform to the following recently published publications of the Indian Standards Institution:

(i)	I.S. 456	Code of Practice for plain and reinforced concrete
(ii)	I.S. 875	Code of Practice for design loads for buildings and structures (Part I to V)
(iii)	I.S. 3370	Code of Practice for concrete structures for the storage of liquids (Part I to IV)
(iv)	I.S. 1893	Criteria for earthquake resistant design of structures
(v)	I.S. 2911	Code of Practice for design and construction of Pile foundations
(vi)	I.S. 2974	Code of Practice for design and construction of machine foundations
		(Part 1 to 4)
(vii)	I.S. 4326	Code of Practice for Earthquake Resistant Design and Construction of
		Buildings
(viii)	I.S. 13920	Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces-
		Code of Practice
(ix)	IRC: 6	Standard specification and Code of Practice for road bridges Loads and
		Stresses
(x)	SP: 16	Design Aids for Reinforced Concrete to IS 456
(xi)	SP: 34	Handbook on Concrete Reinforcement and Detailing

All **Structural steel** design shall conform to the following recently published publications of the Indian Standards Institution:

(i)	I.S. 800	Code of Practice for general construction in steel
(ii)	I.S. 806	Code of Practice for use of steel tubes in general building construction
(iii)	SP: 38	Handbook of Typified Design of Structures with Steel Roof Trusses

10.3 Design Life

The design life of all structures and buildings shall be 60 years.

10.4 Design Loadings

All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; these include dead load, live load, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, and dynamic loads:

Dead Load

This shall comprise all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipments and other items of machinery. In estimating the loads of process equipment all fixtures and attached piping shall be included, but excluding contents, shall be considered.

Dead loads shall be in general as per I.S. 875 Part (I). However, the following **minimum loads** shall be considered in design of structures:

(i)	Weight of water	10 kN/m^3
(ii)	Weight of soil (irrespective of strata available at site and type of soil used for filling etc). However, for checking stability against uplift, actual weight of soil as determined by field test shall be considered	20.00 kN/m^3
(iii)	Weight of concrete	24.00 kN/m^3
(iv)	Weight of reinforced concrete	25.00 kN/m^3
(v)	Weight of Brickwork (exclusive of plaster)	20.00 N/m^2 per mm thickness of brickwork
(vi)	Weight of Solid Concrete Blockwork (exclusive of plaster)	24.00 N/m^2 per mm thickness of blockwork
(vii)	Weight of plaster to masonry surface	18.00 N/m^2 per mm thickness
(viii)	Weight of granolithic terrazzo finish or rendering screed, etc.	24.00 N/m^2 per mm thickness
(ix)	Weight of MS chequered plates	78.5 N/m^2 per mm thickness of plates

Live Load

Live Load (LL) shall include the superimposed loads due to the use/occupancy of the structure/building not including dead, wind or earthquake load. Live loads shall be in general as per I.S. 875 Part (II). However, the following **minimum live loads** shall be considered in the design of structures:

(i)	Live load on roofs	1.50 kN/m^2
(ii)	Live load on floors supporting	
	Equipment such as pumps, valves,	10.00 kN/m^2
(iii)	Live load on all other floors	
	walkways, stairways and	5.00 kN/m^2
(iv)	Live load on Toilet areas	2.00 kN/m^2
(v)	Live load Surcharge for Structures (Retaining walls)	1.2 m Height of soil.

In the absence of any suitable provisions for live loads in BIS Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of the Engineer prior to starting the design work. Apart from the specified live loads or any other load due to material stored, any other equipment load or possible overloading during maintenance or erection/construction shall be considered and shall be partial or full whichever causes the most critical condition.

Wind Load

Wind loads shall be as per I.S. 875 Part (III).

Earthquake Load

Seismic forces shall be as per I.S. 1893.

Dynamic Load

Dynamic loads due to working of plant items such as pumps, blowers, compressors, switch gears, travelling cranes, etc. shall be considered in the design of structures.

Vehicular Wheel Load

For any structure or pipeline below the roads, Class A loading of IRC 6 shall be considered.

10.5 Joints

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the structure. However, contraction joints shall be provided at specified locations spaced not more than 7.5 m in both right angle directions for walls and rafts.

Expansion joints of suitable gap at suitable intervals not more than 30 m shall be provided in walls, floors and roof slabs of liquid retaining structures.

Construction joints shall be provided at right angles to the general direction of the member. The locations of construction joints shall be decided on convenience of construction. To avoid segregation of concrete in walls, horizontal construction joints are normally to be provided at every 2 m height. PVC water stops of 150 mm width shall be used for walls and 230 mm width for base slabs.

10.6 Design Criteria for Underground or Partly Underground Liquid Retaining Structures

All underground or partly underground liquid containing structures shall be designed for the following conditions:

(i) Liquid depth up to full height of wall: no relief due to soil pressure from outside to be considered;
(ii) Structure empty (i.e., empty of liquid, any material, etc.): full earth pressure and surcharge pressure wherever applicable , to be considered ;
(iii) If water table exists, earth pressure to be considered for submerged soil conditions with reference to the geotechnical recommendations ;
(iv) Partition wall between dry sump and wet sump : to be designed for full liquid depth up to full height of wall;
(v) Partition wall between two compartments : to be designed as one compartment empty and other full;
(vi) Structures shall be designed for uplift in empty conditions with the water table as indicated in geotechnical report and minimum factor of 1.2 shall be ensured against uplift or floatation, by considering 0.9 times the characteristic dead load.
(vii) Walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads (Hydrodynamic Impulsive Pressure);
(viii) For general retaining walls and large sized tanks where the walls are designed as retaining walls, sliding check shall also be performed along with over turning checks.
Overturning: The stability of a structure as a whole against overturning shall be ensured so that the restoring moment shall be not less than the sum of 1.2 times the maximum overturning moment due to the characteristic dead load and 1.4 times the maximum overturning moment due to the characteristic imposed loads. In cases where dead load provides the restoring moment, only 0.9 times the characteristic dead load shall be considered. Restoring moment due to imposed loads shall be ignored.
(ix) Sliding: The structure shall have a factor against sliding of not less than 1.4 under the most adverse combination of the applied characteristic forces. In this case only 0.9 times the characteristic dead load shall be taken into account.
(x) All the liquid retaining structures shall be designed for maximum design crack widths of 0.1mm for direct tension and flexure.
(xi) In case of Large and Deep Underground Tanks such as Wet Wells, the analysis can be carried by Finite Element Method using STAAD.Pro or any other equivalent software predominantly used and accepted in the industry.

10.7 Foundations

(i) The minimum depth of foundations for all structures, equipments, buildings and frame foundations and load bearing walls shall be as per IS 1904 but in any case this shall not be less than 1.0 meter in the original soil.
(ii) Maximum safe bearing capacity of soil strata shall be taken as determined by the Contractor through his own independent investigations. Geotechnical reports of proposed STP sites covered under the contract are provided with the Bid Documents. It may be used by Contractor as part of, in addition to, or in lieu of such investigations at his own risk.
(iii) Care shall be taken to avoid the foundations of adjacent buildings or structure foundations, either existing or not within the scope of this Contract. Suitable adjustments in depth, location and sizes may have to be made depending on site conditions. No extra claims for such adjustments shall be accepted by the Employer.
(iv) Special attention is drawn to danger of uplift being caused by the ground water table. All underground structural slabs shall be designed for uplift forces due to ground water pressure.
(v) EGL (Existing ground level) and FGL (Finished ground level) shall be marked on all drawings showing foundation/sub-structure details and related design documents.
(vi) Machine/static equipment foundations shall be separated from adjoining parts of buildings, other foundations and floor/pavement slabs. Joints at floor/pavement slabs shall be suitably sealed.
(vii) Foundations and structures for machines subject to vibrations shall be so proportioned that the amplitude and frequency of the foundation/structure are within the permissible limits as per relevant BIS codes (or as required by the machine vendor).
(viii) Machine foundations shall be designed and detailed as per IS: 2974. All appendages to such foundations shall be reinforced suitably to ensure integral action.
(ix) Pile Foundations - Design, Testing and Execution of piles shall be considered as per provision of relevant codes (conforming to latest version of IS: 2911), and in compliance with the Geotechnical report recommendations as applicable.
(x) Foundations for plant structures in Swampy/Waterlogged areas, for lightly & medium loaded structures and relevant Ground Improvements shall be considered in compliance with the relevant Geotechnical Investigation Report recommendations as applicable. Also to enlist the services of an experienced & specialized agency for all related design aspects considerations, equipment specifications, and implementation methodology, etc., as an advice for the same.

10.8 Design Requirements

The following are the design requirements for all reinforced or plain concrete structures:

a) All blinding and levelling concrete shall be a minimum 100 mm thick in concrete grade M10.
b) All liquid retaining reinforced concrete structures, concrete shall be of a minimum M30 grade with a maximum 20 mm aggregate size for all - structural members and For Buildings, reinforced concrete shall be of a minimum M25 grade (Footings, Plinth Beams, Columns, Slab and beams, etc., i.e. which are other than liquid retaining structures) with a maximum 40 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all other structural members. Further, if there are any liquid retaining RCC tanks coming up with in the buildings, concrete shall be of minimum M30 grade for such RCC tanks also.
c) The reinforced concrete for all structures shall have a minimum cement content of 375 kg/m^3 with a maximum 20 mm size aggregate and 350 kg/m^3 with a maximum 40 mm size aggregate. Reinforced concrete shall have maximum slump of 100mm with maximum water cement ratio of 0.48.
d) As a design consideration to control crack, though general requirements of IS 3370 shall be followed, All liquid retaining structures shall be designed based on the serviceability crack width limit state (i.e. 0.1 mm crack width) and other limit state requirements also to ensure an adequate degree of safety and serviceability.
e) The **minimum cover** to the main reinforcing bars for different members for :

1. Non–liquid retaining structures shall be as follows unless stated otherwise:

Slab (Floor, Roof, Canopy, Chajjas and Staircase)	25 mm
Beams (Sides, Bottom & Top)	40 mm
Lintels (all around)	30 mm
Columns	
(i) For column width 200	40 mm
(ii) For column width 230 & above	50 mm
Pedestals (in contact with earth)	50 mm
Basement wall, retaining walls	
(i) Face in contact with earth	50 mm
(ii) Interior face	40 mm
Foundations (Top, Bottom and sides)	50 mm

2. Liquid retaining structures shall be as follows unless stated otherwise:

Walls - Face in contact with earth	60 mm
Walls - Face in contact with Water	60 mm
Base Slab in contact with Water	60 mm
Base Slab in contact with Soil	60 mm
Launders/Gutter Slabs	45 mm

f) In general, reinforcement for buildings and sewage treatment units shall be HYSD-CRS (Corrosion Resistant Steel) of Grade Fe 500. All physical and chemical properties of this Fe 500 grade steel shall conform to IS: 1786-2008. Welded wire fabric shall conform to IS: 1566 as shown or specified on the drawing. The CRS (corrosion resistant steel) index shall be at least 1.35 when tested for Salt Spray test as per "ASTM B 117 – 2009 test procedure for 120 hours when compared with the Fe 500 normal reinforcement bars and with same bar diameter. All test results (including physical and chemical properties and salt spray tests) have to be produced for the respective bar diameter for each consignment of steel delivered at site and at a frequency of every 20 Metric Tons.

Reinforcement bars and structural steel to be procured only from Primary steel producers with Integrated Steel such as TATA/SAIL/RINL/JSW using iron ore as the basic raw material and having in-house iron making facilities followed by production of liquid steel and crude steel with in-house rolling, adopting BF-BOF route or DRI-EAF technology as per Ministry of Steel guidelines. No Re-rolled material/secondary steel will be accepted or allowed for any structural works.

Only those firms are eligible who are primary steel producer and should have integrated steel plant in single premises.

Certificate issued by ministry of steel of primary steel producer and integrated steel plant having infrastructure in single premises for producing sponge iron, billet and TMT reinforcement bars using iron ore as base material.

The steel manufacturing company should have latest ISO accreditation for Quality Management System.

g) The minimum amount of reinforcement in each of the two directions at right angles within each surface zone should be provided as per clause 8.1 of IS 3370 (Part 2):2009. Definition of surface zones is clearly shown in Figure 1 and Figure 2 of IS 3370 (Part 2): 2009. For slabs, minimum of 10 mm dia bars shall be used to avoid any deformation of lesser diameter bars under loads prior to construction.

h) All buildings shall have a minimum 1 meter wide, 100 mm thick plinth protection paving in M15 grade concrete or stone slabs/tiles. All plinth protection shall be supported on well compacted strata.

i) All pipes and ducts laid below the structural plinth and road works shall be surrounded with concrete of grade M15 having minimum 150 mm thick concrete or D/4 (D = outer dia. of pipe) thickness whichever is more.

j) Use of pressure relief valves to reduce uplift pressure due to ground water table shall not be allowed.

k) Detailing of the reinforcement shall be considered as per latest Indian code of practices and special publications as applicable.

l) Sliding layer or slip layer shall be provided between sub base and structural slab (Raft). Polythene sheets of 500 microns shall be provided as sliding layer as per IS specification.

m) Water tightness testing of water retaining structures shall be done in accordance with IS: 3370, (Part I) - 2009. It is described in **Clause 10.22** of this document. The depth of water for testing shall be up to the soffit of the covering slab.

The following **minimum thicknesses** shall be used for different reinforced concrete members, irrespective of design requirements:

(i)	Walls for liquid retaining structures	250 mm
(ii)	Roof slabs for liquid retaining structures	150 mm
	(Other than flat slabs)	
(iii)	Bottom slabs for liquid retaining structures	300 mm
(iv)	Floor slabs including roof slabs, walkways, Canopy slabs	125 mm
(v)	Walls of cables / pipe trenches, Underground pits etc.	200 mm
(vi)	Column footings	300 mm
(vii)	Parapets, chajja and all fascias	100 mm
(viii)	Precast trench cover	75 mm
(ix)	Column Dimensions a) Exceptional case (Based on any specific requirements)	
	i) To match with width of Block masonry wall	200mm
	ii) To match with width of Brick masonry wall	230mm
	b) In general case	300 mm
(x)	Beams (To match with width of Block masonry wall) :	200 mm
(xi)	Launder Base Slab	200 mm
(xii)	Launder Vertical Wall, Baffle Wall, Gutter Slab	150 mm
(xiii)	Grade Slabs	150 mm

10.9 Materials in General

The term "materials" shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works.

Except as may be otherwise specified for particular parts of the works the provision of clauses in "Materials and Workmanship" shall apply to materials and workmanship for any part of the works.

All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

As soon as practicable after receiving the order to commence the Works, the Contractor shall inform the Engineer of the names of the suppliers from whom he proposes to obtain any materials but he shall not place any order without the approval of the Engineer which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the Engineer informed of orders for and delivery dates of all materials.

Materials shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination failing which such damaged materials will be rejected and shall not be used on any part of the Works under this contract.

10.10 Samples and Tests of Materials

The Contractor shall submit samples of such materials as may be required by the Engineer and shall carry out the specified tests directed by the Engineer at the Site, at the supplier's premises or at a laboratory approved by the Engineer.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer.

The Contractor shall give the Engineer seven days' notice in writing of the date on which any of the materials will be ready for testing or inspection at the supplier's premises or at a laboratory approved by the Engineer. The Engineer shall attend the test at the appointed place within seven days of the said date on which the materials are expected to be ready for testing or inspection according to the Contractor, failing which the test may proceed in his absence unless instructed by the Engineer to carry out such a test on a mutually agreed date in his presence. The Contractor shall in any case submit to Engineer within seven days of every test such number of certified copies (not exceeding six) of the test results as the Engineer may require.

Approval by the Engineer as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer's powers under the Contract.

The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.

10.11 Standards

Materials and workmanship shall comply with the relevant Indian Standards (with amendments) current on the date of submission of the tender.

Where the relevant standard provides for the furnishing of a certificate to the Engineer, at his request, stating that the materials supplied comply in all respects with the standard, the Contractor shall obtain the certificate and forward it to the Engineer.

The specifications, standards and codes listed below are considered to be part of this specification. All standards, specifications, codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions.

In case of discrepancy between the Specification and the Standards referred to herein, the Specification shall govern.

a) Materials

IS: 269 - Specification for 33 grade ordinary Portland cement
IS: 278 - Specification for Galvanized Steel Barbed wire & Fencing
IS: 383 - Specification for coarse and fine aggregates from natural sources for concrete
IS: 428 - Specification for distemper, oil emulsion, colour as required
IS: 432 - Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (Parts 1 & 2)
IS: 455 - Specification for Portland slag cement
IS: 458 - Specification for precast concrete pipes (with and without reinforcement)
IS: 650 - Specification for standard sand for testing of cement
IS: 651 - Specification for salt glazed stoneware pipes and fittings
IS: 808 - Specification for dimensions for hot rolled steel beam, column channel and angle sections
IS: 814 - Specification for covered electrodes for manual metal arc welding of Carbon and Carbon Manganese steel
IS: 1003 - Specification for timber panelled and glazed shutters (Parts 1 & 2)
IS: 1038 - Specification for steel doors, windows and ventilators
IS: 1077 - Specification for common burnt clay building bricks
IS: 1398 - Specification for packing paper, water proof, bitumen laminated
IS: 1489 - Specification for Portland pozzolana cement (Parts 1 & 2)
IS: 1566 - Specification for hard drawn steel wire fabric for concrete reinforcement
IS: 1580 - Specification for bituminous compounds for water proofing and caulking purposes
IS: 1786 - Specification for high strength deformed steel bars and wires for concrete reinforcement
IS: 1852 - Specification for rolling and cutting tolerances for hot rolled steel products
IS: 1948 - Specification for aluminium doors, windows and ventilators
IS: 1977 - Specification for Low Tensile structural steel (Ordinary quality)
IS: 2062 - Specification for steel for general structural purposes (Hot Rolled Low, Medium and High Tensile Structural Steel).
IS: 2185 - Specification for concrete masonry units (Parts 1, 2 & 3)
IS: 2202 - Specification for wooden flush door shutters (Parts 1 & 2)
IS: 2645 - Specification for integral cement water proofing compounds
IS: 2721 - Specification for Galvanized Steel Chain Link Fence Fabric
IS: 2750 - Specification for steel scaffoldings
IS: 2835 - Specification for flat transparent sheet glass
IS: 3384 - Specification for bitumen primer for use in waterproofing and damp proofing
IS: 3502 - Specification for steel chequered plates
IS: 4021 - Specification for timber door, window and ventilator frames
IS: 4350 - Specification for concrete porous pipes for under drainage
IS: 4351 - Specification for steel door frames
IS: 4990 - Specification for plywood for concrete shuttering work
IS: 8112 - Specification for 43 grade ordinary Portland cement
IS: 9862 - Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and chlorine resisting
IS: 10262 - Recommended guidelines for concrete mix design
IS: 12269 - Specification for 53 grade ordinary Portland cement
IS: 12330 - Specification for sulphate resisting Portland cement
IS: 12709 - Glass fibre reinforced plastics (GRP) pipes, joints and fittings for use for potable water supply

b) Tests

IS: 516 - Method of test for strength of concrete

IS: 1182 - Recommended practice for radiographic examination of fusion - welded butt joints in steel plates
IS: 1199 - Methods of sampling and analysis of concrete
IS: 2386 - Methods of test for aggregates for concrete (Parts 1 to 8)
IS: 2720 - Methods of test for soils (Parts 1 to 39)
IS: 2911 - Code of Practice for design and construction of Pile foundations (Part 4)
IS: 3025 - Methods for sampling and test (physical and chemical) for water and wastewater (Parts 1 to 56)
IS: 3495 - Method of test for burnt clay building bricks (Parts 1 to 4)
IS: 3613 - Acceptance tests for wire flux combination for submerged arc welding
IS: 4020 - Methods of tests for wooden flush doors shutters: Type tests
IS: 4031 - Methods of physical tests for hydraulic cement (Parts 1 to 15)
IS: 5807 - Method of test for clear finishes for wooden furniture (Parts 1 to 6)
IS: 7318 - Approval tests for welders when welding procedure approval is not required (Parts 1 and 2)
IS: 13311 - Methods of Non-destructive testing of Concrete- Part 1 & Part 2

c) Codes of Practice for design/detailing

IS: 456 - Code of practice for plain and reinforced concrete
IS: 783 - Code of practice for laying of concrete pipes
IS: 800 - Code of practice for general construction in steel
IS: 806 - Code of practice for use of steel tubes in general building construction
IS: 816 - Code of practice for use of metal arc welding for general construction in mild steel
IS: 817 - Code of practice for training and testing of metal arc welders
IS: 875 - Code of practice for design loads (other than earthquake) for building structures (Parts 1 to 5)
IS: 1081 - Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators
IS: 1172 - Code of practice for basic requirements for water supply, drainage and sanitation
IS: 1477 - Code of practice for painting of ferrous metals in buildings (Parts 1 & 2)
IS: 1597 - Code of practice for construction of stone masonry (Parts 1 & 2)
IS: 1742 - Code of practice for building drainage
IS: 1893 - Criteria for earthquake resistant design of structures
IS: 1904 - Code of Practice for Design and Construction of Foundation in Soils: General Requirements.
IS: 2065 - Code of practice for water supply in buildings
IS: 2212 - Code of practice for brickwork
IS: 2338 - Code of practice for finishing of wood and wood based materials (Parts 1 & 2)
IS: 2394 - Code of practice for application of lime plaster finish
IS: 2395 - Code of practice for painting, concrete, masonry and plaster surfaces (Parts 1 & 2)
IS: 2470 - Code of practice for installation of septic tanks (Parts 1 & 2)
IS: 2502 - Code of practice for bending and fixing of bars for concrete reinforcement
IS: 2571 - Code of practice for laying in-situ cement concrete flooring
IS: 2595 - Code of practice for radiographic testing
IS: 2751 - Recommended practice for welding of mild steel plain and deformed bars for reinforced construction
IS: 2911 - Code of Practice for design and construction of Pile foundations
IS: 2974 - Code of practice for design and construction of machine foundations (Parts 1 to 4)
IS: 3114 - Code of practice for laying of Cast Iron pipes
IS: 3370 - Code of practice for concrete structures for the storage of liquids (Parts 1 to 4)
IS: 3414 - Code of practice for design and installation of joints in buildings
IS: 3558 - Code of practice for use of immersion vibrators for consolidating concrete
IS: 3658 - Code of practice for liquid penetrant flaw detection
IS: 3935 - Code of practice for composite construction
IS: 4000 - Code of practice for High strength bolts in steel structures

IS: 4014 - Code of practice for steel tubular scaffolding (Parts 1 & 2)
IS: 4111 - Code of practice for ancillary structures in sewerage system (Parts 1 to 5)
IS: 4127 - Code of practice for laying of glazed stoneware pipes
IS: 4326 - Code of practice for Earthquake Resistant Design and Construction of Buildings
IS: 4353 - Recommendations for submerged arc welding of mild steel and low alloy steels
IS: 5329 - Code of practice for sanitary pipe work above ground for buildings
IS: 5334 - Code of practice for magnetic particle flaw detection of welds
IS: 5822 - Code of practice for laying of welded steel pipes for water supply
IS: 7215 - Tolerances for fabrication of steel structures
IS: 9595 - Recommendations for metal arc welding of carbon and carbon manganese steels
IS: 10005 - SI units and recommendations for the use of their multiples and of certain other units
SP: 16 - Design Aids for Reinforced Concrete To IS 456
SP: 34 - Handbook on Concrete Reinforcement and Detailing
SP: 38 - Handbook of Typified Design of Structures with Steel Roof Trusses

d) Construction Safety

IS: 3696 - Safety code for scaffolds and ladder (Parts 1 & 2)
IS: 3764 - Safety code for Excavation work
IS: 7205 - Safety code for erection of structural steel work

10.12 General Arrangement of Plant

The following general guidelines shall be followed in the preparation of general arrangement of Plant:

- Sufficient room shall be allowed between items of plant and adjacent Plant or fixed structures to permit safe and convenient access for operation and maintenance;
- An area adjacent to all mechanical Plant shall be provided as maintenance lay down area;
- fixed runways, lifting eyes or other means shall be provided to permit the removal of Plant that may be required to be removed during the course of its normal operational life for maintenance or any other purpose;
- areas where leakage is likely to occur whether in normal use or during maintenance shall be provided with covered drainage channels which shall direct spillage either to a suitable plant drain or to a sump from where it can be pumped to plant drain;

10.13 Orientation

The works shall be laid out within the confines of the Site in order to interface to the existing infrastructure of roadways and inlet and outlet pipe work. Underground services requiring to be relocated in order to accommodate the proposed site layout shall, with the approval of the Engineer, be relocated by the Contractor.

10.14 Buildings and Structures

All the building and structure works shall generally comply with the following Employer's

Requirements unless otherwise specified elsewhere:

1. All building works shall be of reinforced concrete framework (Concrete Grade of M25 as a minimum).
2. All external walls shall be in solid cement concrete blocks of concrete grade M15 and shall be provided as per IS: 2185 (Latest Revision) and shall be 200 mm thick.
3. All internal partition walls shall be in solid cement concrete blocks of concrete grade M15 and shall be provided as per IS: 2185 (Latest Revision). All internal walls shall be 200mm thick except for toilets. Toilet partition walls shall be in 100 mm thick solid concrete block.
4. **(a)** Finishes to concrete liquid retaining structures shall be :
   F1 - External surfaces, buried
   F2 - External surfaces exposed and up to 300 mm below ground level
   F2 - Internal surfaces

(b) Finishes to other concrete structures shall be :

F1 - Buried
F1 - Exposed, where plastering is specified
F 2 - E x p o s e d

The type of finishes are explained in Chapter 4 of Part 10 A "Standard Basic Specifications for Civil and Structural Works"

5. All internal masonry and ceiling surfaces finish shall have 12 mm thick plain faced cement plaster in cement mortar (1:4) with neat cement finish on top. Over this, one coat of primer and two coats of plastic emulsion paint of approved quality and shade shall be provided.
6. All external masonry and concrete with rough board finish shall have 20 mm thick sand faced cement plaster in two coats, base coat 12 mm thick in cement mortar 1:4 and finishing coat 8 mm thick in cement mortar 1:4. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.
7. All external surfaces above ground level shall have one coat of primer and two coats of waterproof cement based paint of approved quality and shade. A coat of silicone water repellent paint shall also be applied thereon.
8. Toilet areas, walls and ceilings, shall have one coat of primer and two coats of plastic emulsion paint.
9. Toilet floor slab shall be filled with brick bat coba (broken bricks in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company.
10. The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.
11. The flooring in all areas except toilets, staircases, pumping stations, chlorination building, centrifuge building, workshop, D.G.Room shall be in 250 mm x 250 mm x 20 mm thick marble mosaic tiles of approved make unless otherwise specified, shade and pattern and placed in cement mortar 1:4 to give overall thickness of 50 mm. Half tile skirting shall also be provided in these areas.
12. The flooring in the pumping stations, chlorination building, centrifuge building, workshop, D.G.Room shall be 60mm thick cement flooring with Metallic concrete hardener topping, under layer of 42mm thick cement concrete 1:2:4 (1 cement : 2 coarse : 4 graded stone aggregate 16mm thick nominal size) and top layer of 18mm thick metallic concrete hardener consisting of mix 1:2 (1 cement : 2 stone aggregate 6mm nominal size) by volume & mixed with metallic hardening compound of approved quality @ 3 kg/m^2. Including cement slurry and rounding off edges.
13. The flooring in operator's room, loading/unloading bay, MCC cum Panel room shall be in 25mm thick Kota stone slab of approved shade and pattern and placed over 20 mm thick base of cement mortar 1:4 to give overall thickness of 45 mm. Half tile skirting shall also be provided in these areas.
14. Toilet areas shall have 450 mm x 450 mm x 25 mm thick polished Kota stone tiles placed in cement mortar 1:4 to give an overall thickness of 50 mm. 2100 mm high dado, in 150 mm x 150 mm x 6 mm thick glazed tiles (approved make, shade and pattern) placed in cement mortar 1:3 shall also be provided in these areas.
15. The flooring along with skirting in administration cum laboratory building shall be 20 mm thick mirror polished, machine cut granite slab of approved shade and pattern placed in cement mortar (1:4). 150mm high skirting shall be provided in these areas. Granite stone shall be provided for laboratory platforms fixed over double sandwiched cuddappah support as directed and the edges of granite is to be embedded into the wall.
16. The toilet facilities shall include at least :
    (i) 2 Nos. Water closets with white porcelain Orissa pan minimum 580 mm long with low level flushing cistern of 10 litres capacity.
    (ii) 2 Nos. Urinals of sizes 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a marble partition of size 680 mm x 300 mm.
    (iii) 2 Nos. wash basins of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.
    (iv) 2 Nos. mirror of size 400 mm x 600 mm wall mounted type fitted over wash basins.

(v) 2 Nos. plastic liquid soap bottles
(vi) 2 Nos. chromium plated brass towel rails minimum 750 mm long.
(vii) All stopcocks, valves and pillar cocks shall be heavy duty chromium plated brass.
(viii) All fittings such as `P' or `S' traps, floor traps, pipes, downtake pipes etc.
(ix) The sewage from toilet blocks shall be led to the wet well of terminal sewage pumping station if present or included under this contract or to the closest gravity sewer.

17. All staircases shall have 25 mm thick chequered mosaic tiles for treads and 25 mm thick plain mosaic tiles for risers of approved make and shade and half tile skirting set in cement mortar in 1:4 to give an overall thickness of 50 mm. All concrete stairs shall have aluminium nosing over 2 mm thick rubber strip of width same as nosing for the full length of the tread. Nosing shall be fixed with countersunk screws.

18. Stairways shall be provided to permit access between different levels within buildings. Staircase shall be minimum 1200mm wide, minimum Tread = 250 mm, maximum Riser = 175 mm and maximum 15 number of steps per flight unless specified otherwise. Staircases in general shall not be steeper than 40°. Staircases having space constraints may be steeper than 40^0. The maximum vertical run for a single flight of stairs shall be 3.0 M.

19. All roof tops and overhead tanks shall be made accessible with ladder provision. Vertical step ladders fitted with landing point extensions will be permitted where considered appropriate by the Engineer to access areas not frequently visited.
Steel staircases shall be constructed of standard channel stringers with M.S. grating treads 25mm thick with non skid nosing. Steel Ladders shall be minimum 600mm wide and shall not exceed 6m of straight run. The ladders shall be painted with epoxy paint.

20. All hand railing shall be provided with Stainless steel SS-304(Schedule 40) with pipe diameter 50 NB. The minimum height of hand railing shall be 1 .2m and maximum spacing of verticals shall be 1.2 m. Number of horizontal rails shall be 3 (1 top, 1 intermediate and 1 bottom) with a 100 x 6 toe plate at the bottom.

21. The reinforced concrete roofs shall be made waterproof by application of an approved roof polythene / bitumen membrane / brick bat coba. The finished roof surface shall have adequate slope to drain quickly the rain water to R.W down take inlet points.

22. All roof floors shall have minimum 750 mm height solid concrete block parapet wall where accessible is provided and shall have minimum 300 mm height solid concrete block parapet wall where accessible is not provided

23. For roofing drainage, cast iron or uPVC rainwater down takes with C.I. bell mouth or uPVC bend and C.I. or uPVC grating at top shall be provided. For roof areas up to 40 sq m minimum two nos. 100 mm diameter down take pipes shall be provided. For every additional area of 40 sq m or part thereof, at least one no. 100 mm dia. down take pipe shall be provided.

24. Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rain water.

25. Building plinth shall be minimum 450 mm above average finished ground level around building or high flood level whichever is more.

26. All doors, windows, rolling shutters shall have lintels above. Chajja protection to lintels on external walls shall be such as to prevent the rain water splashing into the building. Chajja projection of minimum 750 mm for rolling shutters, 600 mm for doors and windows shall be
provided to prevent the rain water splashing into the building. Chajja shall be projected 150 mm on either sides from size of doors/windows/rolling shutters.

27. All windows and ventilators shall have 25 mm thick Kota stone sills bedded in cement mortar (1:3).

28. All doors and windows shall be painted with two coats of synthetic enamel paint over a priming coat (ready mixed Zinc Chromate Yellow primer of approved brand and manufacturer confirming to I.S.: 127-106, 341 and 340).

29. All doors, windows and ventilators shall be made of aluminium confirming to latest version of IS: 1948. All fixtures for doors, windows and ventilators shall also be of aluminium. Aluminium grills shall be provided in all the windows. Doors shall be in two panel and both panels shall be glazed/unglazed. Minimum weight of aluminium doors & windows shall be as follows

I. Single Glazed Window : (Weights indicated shall be aluminium)

a) Openable

Outer Frame	:	Weight 0.70 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.97 kg/RMt
Beading	:	Weight 0.31 kg/Rmt

Fixing Louvers windows/ventilators

Outer Frame	:	Weight 0.46 kg/Rmt

II Double Glazed Window :

Outer Frame	:	Weight 0.72 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.98 kg/Rmt
Beading	:	Weight 0.31 kg/Rmt

III Sliding Windows

Bottom & Top Frame	:	Weight 0.70 kg/m
Shutter Frame	:	Weight 0.42 kg/m
Interlocking Section	:	Weight 0.47 kg/m

IV Aluminium Door

Outer Frame	:	Weight 2.508 kg/Rmt
Shutter Frame	:	Weight 2.508 kg/Rmt
Bottom Stile	:	Weight 2.508 kg/Rmt

Glazing shall be 5.5 mm thick glass.

30. Openings of the windows & ventilators shall be minimum 25% of the external wall area.
31. Ventilator shall be provided where height of floor is more than 3m.
32. All windows and ventilators shall have wire mesh. Frame of doors, windows and ventilators shall be of aluminium of standard rolled section. Doors, Windows and Ventilators shall be of size as per schedule to be submitted by the Contractor for approval of Engineer. The minimum size shall be as per below:
    Door of opening size 1.2m x 2.1m
    Door of opening size 0.75m x 2.1m for toilets
    Glazed windows of minimum size 1.2m x 1.2m
    Ventilators of minimum size 0.6m x 0.6m
33. Rolling shutters shall be made of 80 x 1.25 mm MS laths. Rolling shutter shall be of minimum size 5.0m wide x 5.0m high. Rolling shutter shall be provided in MCC cum panel room, chlorine tonner shed, at entry and exit of the pump house for access to pumps, motors, valves, panels and as wherever required.
34. All concrete channels and ducts used for conveying liquid shall have inside finish of type F2. The width of concrete channels shall not be less than 500 mm. All open channels shall be provided with Aluminium hand railings (3-rail) or concrete walls to a minimum height of 1 m from the access surface elevation. All concrete surfaces of structures conveying raw sewage or primary effluent upstream of the aeration tanks shall be protected from corrosion with an approved internal lining as specified in Clause 10.21 of this document.
35. Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of Factory Act. It shall not be less than 150mm.
36. All exposed surfaces of inserts embedded in concrete shall be painted with two coats of enamel paint over one coat of red oxide zinc chrome primer. Surfaces in contact with concrete shall not be painted.
37. All structural steel members shall be painted with two coats of enamel paint over one shop and one field coat of red oxide zinc chrome primer.
38. All rooms in the treatment plant buildings shall be provided with appropriate sign boards indicating the function of the rooms involved written in Kannada and English Languages.
39. The design of buildings shall reflect the climatic conditions existing on site. Process buildings shall as far as is possible permit the entry of natural light , and the use of glazed panelling shall be kept to a minimum and preference given to wall openings protected by weather canopies.

40. Emergency exit doorways shall be provided from all buildings in order to comply with local and international regulations .Stairways and paved areas shall be provided at the exit points.
41. Toilet blocks in process buildings and control blocks shall be provided with a sink with two drinking water taps of 20 mm size with adequate inlet and outlet connections.
42. All the walkways shall have minimum 1 m width and shall be covered with mosaic tiles. Walkways to be provided with 6063-T6 Aluminium Alloy hand railings.
43. Anaerobic Sludge Digesters and Sludge Tank with Gas Holders shall be built in RCC. A top dome of digesters and Gas Holders shall be made of Steel with full Epoxy Coating as per the specification given in Clause 10.21 of this Part-10 and top surface Ring Beam and top 2m wall of the digester shall also be coated with Epoxy Coating. Contractor may submit his proposal for the alternative materials which can be used for digester dome and gas holder along with all technical details. Employer will approve the type of material which shall be used for the construction of gas holders and digester domes depending upon the durability, corrosion resistivity, strength, ease in operation, functional requirements, economy, etc.(if included in this contract)
44. All concrete structures in contact with sewage and/or sludge upstream of the Aeration Basins shall be provided with full interior corrosion protection linings and/or coatings of appropriate material and thickness to be approved by BDA. This also applies to all concrete structures in contact with any type of sewage sludge anywhere in the plant. For Aeration Basins, interior lining shall extend from the top of wall down to 1.0 meter below the lowest operating water level.
45. For structures containing water or process liquid, the top of the wall shall be atleast 0.5m higher than the maximum water surface level calculated at high flood level and peak plant flow. The top level of internal plant roads and approaches shall be atleast 0.5m above the site High Flood Level.
46. If the High flood level is more than Ground Level then road shall be constructed on the Earthen Embankments/Engineered Embankment. Earthen Embankments/ Engineered Embankment shall be constructed with side slope of atleast 2 horizontal to 1 vertical. Stone pitching shall be provided at both sides of the embankment as per IS: 8237. Top width of embankment shall be taken as 6.0m. Top level of embankment shall be 0.5m above high flood level. Good quality of filling materials can be used for embankment construction as approved by Engineer/as suggested in relevant Geotechnical Investigation Report recommendations as applicable.
47. Engineered Embankments for plant structures in Swampy/Water logged areas shall be considered in compliance with relevant Geotechnical Investigation Report recommendations as applicable.
48. All requirements for Engineered Embankments and all other associated works connected to this system (i.e. like, all controlled filling requirements, Type & suitability of materials, Methodologies, Testing, Protective systems, Aprons, Proper slopes, Stability, Specifications, Quality control, and all other requirements pertaining to this system of works, etc.,) shall be considered in compliance with relevant Geotechnical Investigation Report recommendations as applicable. Also to enlist the services of an experienced & specialized agency for all related design aspects considerations, equipment specifications, and implementation methodology, etc., as an advice for the same (Refer to 46 & 47).
49. Suitable River flow training systems/Flow diversion to be adopted at required locations/places in compliance with relevant Geotechnical Investigation Report recommendations as applicable.

10.15 Roadways, Pathways & Hard standings

A comprehensive network of roadways shall be provided the around treatment plant to link in with the existing road network and permit access to the plant for necessary maintenance, delivery of consumables and personnel access. All roads shall be of Wet Mix Macadam and minimum 6 metres wide excluding shoulders and drains. Vehicular access shall be provided for all Plant structures and buildings. All roads shall be provided with drainage and shall be constructed to prevent standing water.

Paved pedestrian access ways shall be constructed to provide a network of logical routes interlinking plant areas. Damage to any existing roads on account of their use by the Contractor shall be made good to the satisfaction of the Engineer.

Hard standing areas with shading facility shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the works and out again.

10.16 Site Drainage

The Contractor shall provide a site drainage system. The system shall comprise of the following:
- Storm Water Drainage
- Foul Drainage

Storm Water Drainage

Storm water drains adjacent to the existing and proposed roads (under this Contract) shall be sized for a rainfall intensity of 75 mm/hr, allowing for 100% runoff. Drains adjacent to roads shall be in stone masonry in CM (1:4) of appropriate thickness, topped with 75 mm thick M10 concrete and internally flush pointed in cement mortar (1:4), 20 mm thick. The minimum width of drain shall be 450mm.

The storm water drainage system shall also be designed to cater the run-off from the existing plot areas and structures, if necessary depending upon the site topography.

Foul Drainage

The foul drainage system shall accept discharge from toilets, washrooms, offices and the laboratory. The foul drainage system shall be conveyed to either wetwell of the terminal sewage pumping station wherever exist or proposed under this contract or nearest public sewer wherever exist.

10.17 Cable and Pipe work Trenches

Cable and pipework trenches shall generally be constructed in reinforced concrete.

All floor cut-outs and cable ducts, etc. shall be covered with M20 precast concrete covers (Heavy Duty) or MS grating as per direction of Engineer in outdoor areas and M.S. chequered plates, suitably painted of adequate thickness in indoor areas. All uncovered openings shall be protected with hand railing. The pipe, cable trenches shall be suitably sloped to drain off rainwater to a suitable location.

Layout of trenches outside the buildings shall allow space for construction of future trenches where necessary with due consideration for planning for future developments. This aspect shall be brought to the notice of the Engineer while planning the works.

10.18 Pipes and Ducts

R.C.C ducts for drainage shall have minimum 1 metre pre-cast cover (M20 concrete, Heavy duty) while laid under roads. Access shafts of size not less than 600 mm x 1000 mm shall be provided.

All drains (except storm water drains adjacent to roads) shall be covered and designed structurally for appropriate loads.

10.19 Boundary wall , Retaining wall & Main Gate

10.19.1 Boundary wall / Compound wall

Compound wall shall consist of RC precast slab panels (M25) with minimum 60mm thick with Bangalore Development Authority (BDA) / BWSSB Logo, RC post at regular intervals including plinth beam as supports for the panels and necessary RC foundation system for the same along with barbed wire stretched between MS angles fixing at the top of the precast panels with necessary fixtures etc.,

All structural designs and Specifications shall confirm to relevant codal provisions.

An Indicative Typical Boundary wall profiles of TYPE-I & TYPE-II is enclosed as reference for the same. (Refer to Sketch -1, appended in end of 10B)

10.19.2 Retaining wall

1. Retaining wall shall be RCC with M25 grade of concrete. Wall foundations shall be placed on virgin soil and not on backfilled soil. Foundations shall extend to a depth of at least 1.0 metre below finished ground level.
2. Expansion joints shall be provided in the retaining wall.
3. In retaining walls , 100 mm dia weep holes shall be provided at 1 m vertically and horizontally. The lowest weep hole shall be at about 30 cm above the ground level. All weep holes shall be surrounded by loose stones and shall have sufficient fall to drain out the water quickly.

10.19.2 Main Gate

Each proposed treatment plant shall have one main gate to access the plant irrespective of existing gate at the premises of existing plant site. Minimum width of main gate shall be 6.5m. Main gate shall have 1.5m wide wicket gate. Main gate shall have as external framework of GI pipes and internal framework of MS flats. Gate shall be fixed on RCC columns. The design and pattern of gate with drawing shall be submitted for approval of the Engineer. The gate shall have all necessary hinges, locking arrangement, rolling arrangement and painting complete, as approved by the Engineer.

10.20 Landscaping

The site shall be landscaped once the Works are substantially complete. Landscaping area shall be marked in the layout plan of STP site.

Landscaping shall include planting of suitable trees and development of lawn/grassed areas. Landscaping in general shall meet ecological and environmental conditions of the site. Road widths shall determine the size of the tree height and spread to be selected for planting. Trees suitable for local conditions shall be selected as approved by the Engineer. Medicinal and fruit trees shall be avoided. Landscaping shall be maintained in good condition till the completion of the contract.

Area for landscaping will be equal to total area of project site minus area for the treatment plant units and the area required for roads, sidewalks and drains.

10.20.1 Tree Planting

Pits dug a few days in advance of actual planting shall be allowed to weather and be filled with top soil mixed with manure. Size of the pit shall be as per standard requirement. Only one tree shall be planted in each pit. A guard made of bamboo with wire mesh or bricks or M.S. ring as approved by Engineer, shall be provided.

10.21 Specification for Anti-Corrosive Internal Coating/Lining protection of Concrete Surfaces

Application limits of Anti-Corrosion Internal Coating/Lining for Concrete Surfaces:

1. All units upstream of and including Primary Clarifiers will have to be provided with internal coating/lining for the full internal surface area (Walls and base slab)
2. For the units - Anaerobic Zone, Anoxic Zones, Aeration Zones and Aeration Basin Effluent Channels, internal coating/lining shall be provided on the walls only from the top of the structure to 1.0 m below the lowest operating liquid level
3. For the units handling the solids part such as: Gravity Sludge Thickener, Anaerobic Sludge digester and Digested Sludge and Biogas Storage tank, internal lining shall be provided for the entire internal surface area.

Contractor shall adopt any one of the following materials for internal coating/lining and submit his methodology for approval of Engineer.

10.21.1 Intertol Poxitar or equivalent

This is a two component reaction hardening coating of low solvent content based on a coal tax epoxy combination with mineral fillers manufactured by Sika India Pvt Ltd, which is provided for long term protection to concrete and steel structures against chemical corrosion. This component has excellent resistant to water and chemicals. It has resistant to microbes also.

10.21.1.1 Application Methodology

For steel structure, sand blasting or wire brushing is essential. Surface of steel shall be free from oil, dirt and grease. For Concrete structure, remove cement skin, loose particle from the surface. Cavities, pin holes should be levelled.

For Concrete structure, surface shall be primed using 1 part of Inertol Poxitar and 5% Sika Thinner DS. Surface shall be primed using above materials at a rate of 0.20 kg/ m^2.

As seal coat, two coats of Inertol Poxitar is applied with rate of 0.20 kg/ m^2 per coat. Inertol Poxitar is basically consisting of two parts Part-A & part-B. Part A and part-B are mixed in 16:84 ratios (by weight).

For Steel Structure, surface shall be primed with Fraizinc-R with the rate of 0.20 kg/ m^2. After this, two coats of Inertol Poxitar is applied over the primer with the rate of 0.20 kg/ m^2 per coat.

Part-A & part-B are mixed thoroughly with electric stirrer with up and down movement. These shall be mixed for at least 3 minutes. Apply mix with by brush or roller. Over coating shall be done after minimum 4 hours or maximum 7 days.

Properties of Inertol Poxitar are given below:

Colour	Black		
Solids by weight	77%		
Mixed Density	1.50 at 27° C		
Pot Life	At 30° C 120 Minutes		
Over-coating Time	**Subs Temp**	**Min**	**Max**
	10° C	16 hours	7 days
	20° C	8 hours	7 days
	30° C	4 hours	7 days
Mixing Ratio	Part A : part B =16:84 (by Weight)		
Curing Time	7 days		

10.21.2 Shalipoxy-CTE or equivalent

Shalipoxy-CTE is a two component Coal Tar Epoxy coating manufactured by Shalimar Tar Product limited, black in colour, used to protect steel, concrete structures in corrosive environment. It cures to a hard smooth surface and possesses exceptional resistance to the effect of water immersion, salt water, oils, acids, minerals, crude oils etc.

10.21.2.1 Application Methodology

For Concrete Structures- Mechanical grinding or other suitable surface preparation is recommended for obtaining best results on concrete. Compressed air is used to remove residual dust or use brush to remove dust completely. Compressed air should be oil free. Apply only to dry surface.

For Steel Structures- Steel structures which are to receive Shalipoxy-CTE coating should be prepared by sandblasting or power tool or mechanical cleaning to a commercial Grey metal finish. If moisture or other contaminants contaminate prepared surface, they should be reblasted. Use suitable Shali Zinc Epoxy primer over the prepared surface.

Mix (by volume) 4 parts of Component A to 1 part of Component B by stirring thoroughly for at least 3 minutes. Allow the mix to stand for 10 minutes before application.

Apply two coats of Shalipoxy-CTE by brush, roller or spray. First coat should be allowed to dry tack before application of second coat. The second coat should be applied within 72 hours, wipe first coat with MIBK and wipe dry with cloth before second coat.

Covering capacity of Shalipoxy-CTE for concrete structure shall be 4 m^2 per litre per coat and for Steel structures it shall be 6 m^2 per litre per coat.

Properties of Shalipoxy-CTE are given below:

Colour	Black
Solids by weight	76%
Pot Life	At 30° C 240 Minutes
Over Coating Time	12 Hours
Curing Time	7 days
Dry Film Thickness , in two Coats	300 Microns

10.21.3 Masterseal-SP120 or equivalent

The high build , pitch extended epoxy coating shall be MASTERSEAL SP 120 manufactured by BASF Construction Chemicals, a 100% solids, solvent free, tough abrasion resistant protective coating. The product shall exhibit excellent bond strength with the substrate at least exceeding 2.5 MPa, when tested as per ASTM D4541. The product shall be formulated have high build thickness exceeding 150 microns per coat on average and shall be applied to achieve overall thickness of 300 microns in two coats. The product shall be formulated to resist exposure to accelerated weathering test as per ASTM D4587 and shall not exhibit any flaking or blistering.

10.21.3.1 Application Methodology

Concrete Structure- First it shall be ensured that concrete shall be at least 28 days old and sound. Oil, grease, mould release agent, curing membrane and such other contaminants must be removed by mild detergent and water, and by thoroughly scrubbing with a soft brush. If the wall surface is damp or water is seeping out, stop the leakage before coating. Even out all unevenness such as blow holes , pin holes and other surface defects with CONCRESIVE 2200 manufactured by BASF Construction Chemicals India Private Limited , before application of coating.

Steel Structures- Remove all previous treatments and corrosion products by sand/shot blasting to bright metal finish. Do not allow long time gap between surface preparation and the coating to prevent re-oxidising of metal before application of product.

Masterseal SP120 is two component products, Masterseal SP120 Base and Masterseal SP120 Hardener. Both these products are mixed in ration 1:1 (by weight) Mix both the components for 3 minutes with a slow speed drill and wing style mixing paddle at 300-400 rpm until a homogeneous colour is achieved. Keep the paddle below the surface to avoid entrapping air. This shall be applied in two coats, each at a W.F.T. of 150 microns. The second coat applied after first coat has dried (4-6 hours) and at right angles to it. Should the application of second coat be delayed, abrade the previous coat to give an adequate mechanical key and wipe with SOLVENT NO 2 before application.

Properties of Masterseal SP120 are given below:

Colour	Black viscous liquid
Solids by volume	100%
Mixed Density	1.65 Kg/l at 27° C
Pot Life	At 25° C 60 Minutes At 40° C 30 Minutes
Over Coating Time	12 Hours at 25° C
Mixing Ratio	Part A : part B =1:1 (by Weight)
Curing Time	5 days
Dry Film Thickness , in two Coats	300 Microns

10.21.4 Nitocote ET550 or equivalent

Nitocote ET 550 is a Epoxy tar based high performance resin coating Thixotropic pitch extended epoxy amine adduct formulation containing reinforcing inert fillers and special blend of solvents. The product is supplied as a two-component system comprising a special blend of an epoxy resins and a separate low viscosity amine hardener. Nitocote ET 550 is applied as a two coat application. It is generally applied at a wet film thickness of 265 micron per coat (175 microns DFT per coat). The product shall exhibit excellent bond strength with the substrate when tested as per specification.

10.21.4.1 Application Methodology

All surfaces to be treated with Nitocote ET550 must be clean and free from dust or loose material.

Concrete Structure- All laitance must be removed by grit blasting or other suitable removal methods. The general standard of surface preparation should be in accordance with ACI 503R-89, Chapter 5 paragraph 5.4. Following the preparation of a concrete structure, care should be taken to ensure that any surface irregularities are filled with Nitomortar FC

Steel Structures- Any metal surface should be grit blasted to a bright finish, meeting the requirements of Swedish Standards SA 21/2. BS4232, First Quality .All metal surfaces should be coated immediately after preparation.

10.21.4.2 Mixing

Nitocote ET550 should always be mixed in an open, well ventilated area. The contents of the base shall be stirred thoroughly to disperse any settlement. The entire contents of the hardener shall be poured into the base container ensuring that the sides and bottom of the container are well scraped. The two components should be mixed mechanically using a mixing paddle fitted on a heavy duty, slow speed electric drill. The mixing should be carried out continuously for 3-5 minutes, until a uniform consistency is achieved.

Application: Brush application

Nitocote ET550 should be applied in two coats. The thoroughly mixed material should be applied with a suitable brush. The first coat must be firmly applied and be well scrubbed into the surface, ensuring a uniform coating with a wet film thickness not less than 265 microns, be allowed to dry for not less than 16 hours at 20°C. The second coat should be applied as above, again achieving a wet film thickness of 265 microns. The number of coats to achieve a total wet film application of 530 microns.

10.21.4.3 Properties of Nitocote ET550 are given below:

Sr.no	Property	Allowable Standard	Method
1	Dry Film Thickness , in two Coats		
2	Adhesive bond strength	:>1.5 N/mm2	ASTM D 4541
3	Hardness Test		
a)	Gauge Hardness	H to 6H	ASTM-D 3363-92a
b)	Scratch Hardness	H to 6H	ASTM-D 3363-92a

Chemical Test

	Specimens Immersed for 30 days in		
1)	H^2 SO_4 1%		ASTM-C 210-92
2)	NaOH 1 %		ASTM-C 210-92
3)	Deionsed water		ASTM-C 210-92
4)	HNO_3 10%	No attack	
5)	NaOH 30%	No attack	
6)	Period of Exposure to methane at 2.0 kg/sq.cm pressure for 720 hours	No attack	BS 5493

No attack means no signs of swelling, scratches, peeling or discolouration of Epoxy Tar specimen

10.21.5 Interzone 954

Two-component, high build modified epoxy barrier coat - hydrocarbon modified epoxy cured with a cycloaliphatic amine adduct curing agent, and formulated to give good barrier protection in

both immersed and external atmospheric exposure conditions. The product is supplied as a two-component system comprising of a pigmented epoxy base and a clear amine curing agent.

The product is supplied as a two-component system comprising a special blend of an epoxy resins and a separate low viscosity amine hardener. The coating can be applied as a single coat system achieving a dry film thickness of 500 microns (588 microns wet film thickness) sprayed in one coat.

10.21.5.1 Application Methodology

Surface Preparation

Concrete Structure- Surfaces must be clean, dry and free from curing compounds, laitance, releasing compounds, oil, grease, dirt, chalk, or previously applied coatings. Laitance must, therefore, be removed by sweep blasting or other means prior to coatings application. Ensure that the concrete is sufficiently dry to receive coatings; use a moisture meter. The 6% maximum moisture content shall be permissible. A primer coat of a solvent-free epoxy primer must be applied at a thickness of 40-50microns before application of the topcoat.

Steel Structures- All surfaces to be coated must be clean and free from dust or loose material. Interzone 954 can be applied directly to blasted steel as per SSPC/SP-6, a minimum surface profile of 50- 75 microns is recommended.

Previously Painted Surfaces - Remove all rust, rust scale, other corrosion products, loose or heavy chalk and loose or scaling paint by "Hand or Power Tool Cleaning" (SSPC-SP2 or 3 respectively / AS 1627 St2 or St3). "Feather" thick edges of existing coating. Sand or sweep blasts any glossy areas until dull. Spot prime bare areas as recommended.

10.21.5.2 Mixing

The mixing ratio of Base (Part A) to Curing Agent (Part B) is 4:1. Material is supplied in two containers as a unit. Always mix a complete unit in the proportions supplied. The product, once mixed, must be used within the working pot life specified.

1. Agitate Base (Part A) with a power agitator
2. Combine entire contents of Curing Agent (Part B) with the Base (Part A) and mix thoroughly using a power agitator.

Application: Airless Spray Application

Airless spray is the preferred method of application as air spray techniques will not produce satisfactory film build without the need for "multiple pass" applications. The pump should have a minimum ratio of 45:1. It is also advisable to check that adequate air volume is present

.

Airless Spray

Tip Range: 0.53-0.66mm (21-26 thou)
Total Output: Minimum 176kg/cm2
Fluid Pressure: 2500 p.s.i

10.21.5.3 Properties of Interzone 954 are given below:

Sr.no	Property	Allowable Standard	Method
1	Dry Film Thickness , in a single coat	500 microns	DFT gauge
2	Adhesive bond strength	Not less than 10MPa (10 N/mm2)	ISO 4624
3	Tensile Strength	An average of 11MPa (11 N/mm2)	ASTM D2370
4	Abrasion Resistance	Average of 88mg weight loss per 1000 cycles using CS10 wheels and a 1Kg loading.	ASTM D4060
5	Immersion	No film defects after 1 year of exposure	ISO 2812 Part 2 - "Resistance to water immersion @ 40°C"
6	Impact Resistance	Direct Impact Resistance – 2.5 Joules	ASTM D2794

Chemical Test

	Specimens Immersed for 30 days in		
1)	H_2SO_4 1%	No attack	ASTM-C 210-92
2)	NaOH 1 %	No attack	ASTM-C 210-92
3)	Deionised water	No attack	ASTM-C 210-92
4)	Period of Exposure to methane at 2.0 kg/sq.cm pressure for 720 hours	*No attack	

*No attack means no signs of swelling, scratches or peeling of coating specimen

10.21.5.4 Application Methodology

Surface Preparation

Concrete Structure- Surfaces must be clean, dry and free from curing compounds, laitance, releasing compounds, oil, grease, dirt, chalk, or previously applied coatings. Laitance must, therefore, be removed by sweep blasting or other means prior to coatings application. Ensure that the concrete is sufficiently dry to receive coatings; use a moisture meter. The 6% maximum moisture content shall be permissible. A primer coat of a solvent-free epoxy primer must be applied at a thickness of 40-50microns before application of the topcoat.

Steel Structures- All surfaces to be coated must be clean and free from dust or loose material. Interzone 954 can be applied directly to blasted steel as per SSPC/SP-6, a minimum surface profile of 50- 75 microns is recommended.

Previously Painted Surfaces - Remove all rust, rust scale, other corrosion products, loose or heavy chalk and loose or scaling paint by "Hand or Power Tool Cleaning" (SSPC-SP2 or 3 respectively / AS

1627 St2 or St3). "Feather" thick edges of existing coating. Sand or sweep blasts any glossy areas until dull. Spot prime bare areas as recommended.

10.21.5.5 Mixing

The mixing ratio of Base (Part A) to Curing Agent (Part B) is 4:1. Material is supplied in two containers as a unit. Always mix a complete unit in the proportions supplied. The product, once mixed, must be used within the working pot life specified.

1. Agitate Base (Part A) with a power agitator
2. Combine entire contents of Curing Agent (Part B) with the Base (Part A) and mix thoroughly using a power agitator.

Application: Airless Spray Application

Airless spray is the preferred method of application as air spray techniques will not produce satisfactory film build without the need for "multiple pass" applications. The pump should have a minimum ratio of 45:1. It is also advisable to check that adequate air volume is present.

Airless Spray

Tip Range: 0.53-0.66mm (21-26 thou)
Total Output: Minimum 176kg/cm2
Fluid Pressure: 2500 p.s.i

10.21.5.6 Properties of Interzone 954 are given below:

Sr.No	Property	Allowable Standard	Method
1	Dry Film Thickness, in a single coat	500 microns	DFT gauge
2	Adhesive bond strength	Not less than 10MPa (10N/mm2)	ISO 4624
3	Tensile Strength	An average of 11MPa (11N/mm2)	ASTM D2370
4	Abrasion Resistance	Average of 88mg weight loss per 1000 cycles using CS10 wheels and a 1Kg loading.	ASTM D4060
5	Immersion	No film defects after 1 year of exposure	ISO 2812 Part 2 - "Resistance to water immersion @ 40°C"
6	Impact Resistance	Direct Impact Resistance – 2.5 Joules	ASTM D2794

Chemical Test

	Specimens Immersed for 30 days in		
1)	H_2SO_4 1%	No attack	ASTM-C 210-92
2)	NaOH 1 %	No attack	ASTM-C 210-92
3)	Deionised water	No attack	ASTM-C 210-92
4)	Period of Exposure to methane at 2.0 kg/sq.cm pressure for 720 hours	*No attack	

*No attack means no signs of swelling, scratches or peeling of coating specimen

10.22 Hydraulic Testing of Liquid Retaining Structures

In addition to the structural test of structures as applicable, the liquid retaining structures shall also be tested for water tightness test at full supply level as described in clauses 12.1,12.1.1, 12.1.2 and 12.1.3 of latest version of IS 3370 (Part I).

On completion of the structure and before its commissioning, the Contractor shall carry out a water tightness test for the maximum water head condition i.e. with the water standing at Full Supply Level(FSL). This test shall be carried out preferably in dry season and prior to internal coating/lining in accordance with the procedure given below:

The water tightness test shall be carried out when the construction of liquid retaining structure is done and when it is possible to fill the structure and ensure that uniform settlement of the structure as a whole or as directed by the Engineer. Before the filling operations are started the structure shall be inspected by the Engineer and the Contractor's Representative and the condition of surfaces of walls, contraction joints shall be noted and it shall be ensured that the jointing material filled in the joint is in position and all openings are closed. The Contractor shall make necessary arrangement for ventilation and lighting of the structure by way of floodlights, circulators etc. for carrying out proper inspection of the surfaces and inner conditions if so desired by the Engineer. Records of leakages starting at different levels of water in the reservoir, if any, shall be kept.

The liquid retaining structure once filled shall be allowed to remain so for a period of seven days before any readings of drop in water level are recorded. The level of the water shall be recorded against the subsequent intervals of 24 hours over a period of seven days. The total drop in surface level over a period of seven days shall be taken as an indication of the water tightness of the structure, which for all practical purposes shall not exceed 40 mm. Also there shall be no indications of the leakages around the opening or on the walls.

If the structure does not satisfy the condition of test and the daily drop in water level is decreasing, the period of test may be extended for a further period of seven days and it the specified limit is then reached the structure may be considered as satisfactory.

The external faces of structure shall not show any signs of leakage and shall remain apparently dry over the period of observation of seven days after allowing a seven day period for absorption after filling.

In case the drop in level exceeds the permissible level limit and signs of leakage with the stipulated period of test, the Contractor shall carry out such additional works and adopt such measures as may be directed by the Engineer to reduce the leakage within the permissible limits. The entire rectification work that shall be carried out in this connection shall be at the Contractor's cost. The water required for subsequent testing shall be supplied to the Contractor free of cost, if the same is available near the site. Contractor shall have to make arrangement for filling emptying the structure at his own cost.

If the test results are unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the water retaining structures test procedures, at his own cost. Should the re-test results still be unsatisfactory after the repairs, the structure will be condemned and the Contractor will dismantle and reconstruct the structure, to the original specification, at his own cost.

During testing and during defect liability period the impression marks created due to seepage shall be rectified and made good.

No separate payment shall be made for water tightness test and the cost thereof shall deem to be covered in the rates quoted of different items of work of Treatment Plant.

10.23 Non Destructive Testing of RCC Structures

Non Destructive Testing (NDT) shall be carried out as per latest version of IS: 13311 codes as per the instruction given by Employer.

10.24 Rain water harvesting system.

The Rain water harvesting for the proposed STP shall be carried out in line with the regulatory guidelines specified by Bangalore Development Authority (BDA).

10.24.1 Need for Rain water Harvesting

10.24.1.1 Rainwater harvesting at STP site shall be carried out in view of the following:

a) Conserving rainwater

b) Possibility of integrating the storm water drainage scheme of the STP with rain water conservation.

10.24.1.2 The convenient and economical way of achieving the same is by adopting roof water harvesting methodologies.

10.24.2 Components of the Rain Water Harvesting Scheme

10.24.2.1 Rainwater harvesting carried out for enriching the groundwater resources essentially consists

a) common collection tank; and b) pipeline(s)

10.24.2.3 Following are the main components proposed for the roof water harvesting system at the STP including their location in the project area:

a) Rainwater pipes from the roofs of all the Buildings;

b) First flush piping system

c) Storm water drains adjoining the roads of the plant;

10.24. 3Integration with Storm Water Drains

The roof water from all Buildings, etc. shall be collected and integrated with all storm water drains of the main plant area. The average annual rainfall data for Bangalore is around 1000mm/ 39.4 inches (100 years average rainfall data).

10.25 Exterior Surface Painting:

Exterior surface of all STP units shall be painted with approved quality exterior paint as per specification. Multi colour artistic / impressive painting work suiting to the landscape features and surrounding environment shall be done to improve the aesthetics of the structure. The decision of Bangalore Development Authority (BDA) - Engineer In Charge / Consultant Architect is final in selecting the colour / art for the structures.

End of Part 10B

PART 11: Major Strctures and Mechncial List

(Below list is for reference and tender purpose only)

For 25 MLD capacity STP

Description	Length /Dia in m	Width in m	SWD/LD /Ht in m	FB in m	QTY	Remarks
Dimension of receiving chamber:	3	2.60	2.5	0.5	1Nos	
Dimension of Coarse Screen Channel: Mechanical Screen (1 No) with spacing 10 mm	13.00	2.60	1.00	0.50	1 Nos	
Dimension of Wet Well	10.00		2.00	0.00	1 Nos	
Dimension of receiving chamber:	3	2.6	2.5	0.5	1Nos	
Dimension of Fine Screen Channel: Mechanical Screen (1 No) with 6mm bar spacing	13.00	2.60	1.00	0.5	1 Nos	
Dimension of Grit Chamber:	4.4	4.4	0.9	0.5	2 Nos	
Dimension of Pharshall flume:	12	0.3	2	0	1	
Dimension of EQT & ANOXIC	46.5	46	5	0.5	1No	
Dimension of SBR Tank :	28.00	28.00	6.00	0.50	4 Nos	
Dimension for Treated sewage tank :	7.7	7.7	3.0	0.5	1No	
FILTRATION BAY PLATFORM DIMENSIONS	20.0	40.0	NA			platform
Chlorine contact tank	25	9	3	1	1 No	
Sludge Sump (to collect extra sludge from SBR process)	4.2	4.2	3.5	0.5	1 Nos	
Sludge Thickener	11.50		4.00	0.50	1 Nos	
Thickened sludge sump (under flow from thickner to be processed through entrifuge)	2.40	2.40	2.50	0.50	1 No	
Dimension of Centrate / Supernatant Sump	2.20	2.20	2.50	0.50	1No	
Size of the Dewatering building	10.00	5.00	4.00		1No	G.F
	10.00	5.00	5.00			F.F
Chlorination Building	10	5	5		1 No	
Dimension for Air Blower Room -Aeration & Mixing	20	10	5		1No	
Dimension for Air Blower Room -Filter	5	5	5		1No	
Dimension for Ozone room	5	5	5		1No	
Administration Building						
Office, Laboratory, Stores and workshop, MCC Room,	15	10	4			G.F
PLC SCADA, Meeting Room,	15	10	4			F.F
Transformer Yard	10	10				Fencing
Security Room	5	3	3.5			
Compound wall min 2.5 m height						As per Layout

Description	Length /Dia in m	Width in m	SWD/LD /Ht in m	FB in m	QTY	Remarks
Road min 6.0 m wide & Drain						As per Layout

MECHANICAL EQUIPMENT LIST for 25 mld capacity STP

Equipment	Specification	Type	MOC	Qty	UNIT
Manual coarse Screen	2.6m Width X 1.5m Ht ,10 mm Opening space	60 Deg Manual Fine Screen	SS 304	1	No
Raw sewage transfer pump:	Provide capacity of 1200 m3/hr @ 20 m, submersible cutter pump 3 nos - 2w+1sb	Submersible cutter type	CI/SS 304	3	Nos
Manual Fine Screen	3.0m Width X 1.5m Ht ,6 mm Opening space	60 Deg Mechanical Fine Screen	SS 304	1	Nos
Mechancial Fine Screen	3.0m Width X 1.5m Ht ,6 mm Opening space	60 Deg Mechanical Fine Screen	SS 304	1	Nos
Grit Chamber mechanism	4.4 m X 4.4 m X 1.4 m HT	Grit With Classifier	MSEP	2	Nos
Submersible Mixer in Anoxic tank	3 Kw submersible mixer to be provided in Anoxic Zone (2 Nos)	Submersible	SS 304	2	Nos
Mixing air blowers in ET	3 nos-2w+1sb, 2100 m3/hr, 6 mwc air blowers, about 67 BHP for blowers (to be checked during detailed engg after account for motor HP)	Tri Lobe Blower	CI	3	Nos
SBR-Decanter		by hydro lifting	SS 304	4	Nos
Aeration Blower	Provide 1800m3/ hr @ 0.6 kg/cm2 air blowers, 4 working + 1 standby, about 60 BHP of blower (to be verified during det. Engg., based on motor HP)	Tri Lobe Blower	CI	5	Nos

Equipment	Specification	Type	MOC	Qty	UNIT
Diffusers for SBR process	air supply through EPDM tubular 90mm dia x 990mm long diffusers, about 900 numbers	Tubular membrane type	EPDM	900	Nos
RAS pumps	Provide 65 m3/ hr @ 10 mwc, horizontal centrifugal, non clog, semi open impeller pumps - 4w+1sb - 5 nos.	Submersible	CI/SS 304	4	Nos
SAS PUMPS	Provide 92 m3/ hr @ 18 mwc, horizontal centrifugal, non clog, semi open impeller pumps, 4w+1sb- 5 nos	Submersible	CI/SS 304	4	Nos
Filter feed pump	Provide 1200m3/ hr @ 35mwc, horizontal centrifugal, closed impeller, clear water pumps, 1w+1sb-2 nos.	Horizontal Centrifugal	CI/SS 304	2	Nos
DISC FILTER / ONLINE AUTO WASH FILTER	Provide 1200m3/ hr Capacity of Disc Filter /Auto wash filter with 50 Micron rating - preferred make: AZUD / ARKAL / AMIAD	Disc Filter	HDPE	1	Nos
Glass Media FIlter	3.0 m Dia X 5.5m Los	Horizontal	MSRL	5	Nos
Activated Carbon Filter	3.0 m Dia X 6.1m Los	Horizontal	MSRL	5	Nos
Glass Media	High-calibrated granulometry minimum 0,4 mm. 0,7 mm. on average.			225600	kg
Carbon Media	Iodine value 1100			84400	kg
Stainer	Umberlla type K1 Type		PP	10500	nos
Filter Backwash Pump	300 m3/h@ 25m Head	Horizontal Centrifugal	CI/SS 304	3	Nos
Air Scour Blower	1000 m3/h@ 5m Head	Horizontal Centrifugal	CI/SS 304	2	Nos
Chlorine Tonner	No of 980 kg.			4	Nos

Equipment	Specification	Type	MOC	Qty	UNIT
Chlorinator	6 Kg /h			4	Nos
Chlorine Booster Pump	10 m3/h@ 15m Head	Horizontal Centrifugal	CI/SS 304	2	Nos
Ozonator (optional)	Corona discharge ozonator, with oxygen concentrator and all accessories, about 5.5 kg/h , 2 nos - 1w + 1sb			2	Nos
THICKENER FEED PUMP	Provide 25 m3/ hr @ 18 mwc pumps Horizontal Centrifugal, non clog, semi open impeller type , 2 nos - 1w+ 1 sb	Horizontal Centrifugal	CI/SS 304	2	Nos
SAS SLUDGE THICKNER	11.5 m Dia X 3.5 SWD thickner mechanism	Central Shaft driven	MSEP	1	Nos
Service water for dilution & flushing in thickener	35m3/ hr @ 15 mwc Horizontal Centrifugal, non clog pumps - 2 nos - 1w+1sb	Horizontal Centrifugal	CI/SS 304	2	Nos
THICKENED SLUDGE TRANSFER PUMPS	Provide 5.0m3/ hr @ 15 mwc Capacity of pumps of 1 working + 1 standby (Screw Pump type)	Screw Pump	CI/SS 304	2	Nos
Centrifuge Unit	5.0 m3/h	Drum type	SS	2	Nos
Supernatant transfer pump:	Provide 2nos - 1w+ 1sb pumps with capacity of 35 m3/hr @ 14 mwc (Horizontal Centrifugal, non clog pumps)	Horizontal Centrifugal	CI/SS 304	2	Nos
POLYELECTROLYTE DOSING Tank	0.5 m3	Vertical	HDPE	2	Nos
AGITATOR FOR POLYELECTROLYTE DOSING Tank	Slow speed agitator for mixing	TOP MOUNTED	SS 304	2	Nos
POLY DOSING PUMP	50 LPH@ 5.0 BAR		PP	2	Nos
Safety Shower			PVC	1	No
Monorail in Blower House	1 ton			1	No
Monorail in Chlorine Tonner	1 ton			1	No
Monorail in Dewatering Building	1 ton			1	No

50 MLD SBR PROCESS - CIVIL LIST

Description	Length /Dia in m	Width in m	SWD/LD /Ht in m	FB in m	QTY	Remarks
Coarse Screen Channel	13.00	2.50	1.00	0.5	1 Nos	
Wet Well (Circular)	14.00		2.00	0.5	1 nos	
Fine Screen Channel: Mechancial Screen & Manual Screen	15.00	3.00	1.00	0.5	1 nos	
Grit Chambers	6.2	6.2	0.9	0.5	2 Nos	
Parshall flume channel	12	0.3	2	0	1	
Equalization & ANOXIC tank	60	60	5	0.5	1No	
SBR Tanks	40.00	40.00	6.00	0.50	4 Nos	
Treated sewage tank :	11.0	11.0	3.0	0.5	1No	
Chlorine contact tank :	42	10	2.5	0.5	1 No	
Sludge Sump :	6.0	6.0	3.5	0.5	1 Nos	
Sludge Thickener :	16.50		4.00	0.50	1 Nos	
Thickened Sludge Sump :	1.60	1.60	2.50	0.50	1 No	
Centrate / Supernatant Sump :	3.40	3.40	2.00	0.50	1No	
Dewatering building	10.00	5.00	4.00		1No	G.F
	10.00	5.00	5.00			F.F
Chlorination Building	15	5	5		1 No	
Air Blower Room -Aeration and ET	20	10	5		1No	
Air Blower Room -Filter and Ozone room	10	5	5		1No	
Office, Laboratory, Stores and workshop,MCC Room,	15	10	4			G.F
PLC SCADA, Meetimg Room,	15	10	4			F.F
Transformer Yard	10	10				Fencing
Security Room	5	3	3.5			
Glass media filter and carbon filter bay	60	20				only platform
Compound wall with MS Gate at two places						As per Layout
Rooad & Drain						As per Layout

50 MLD EQUIPMENT BOQ AND INDICATIVE COST

Equipment	Specification	Type	MOC	Qty	UNIT
Manual coarse Screen	2.5m Width X 2.0m Ht ,10 mm Opening space	60 Deg Manual Fine Screen	SS 304	1	No
Raw sewage transfer pump:	Provide 1Nos of pumps with capacity of 2350 m3/hr @ 20 m with 2 working and 1 standby pumps (submersible cutter Type)	Submersible cutter type	CI	3	Nos
Manual Fine Screen	3.0m Width X 1.5m Ht ,6 mm Opening space	60 Deg Mechanical Fine Screen	SS 304	1	Nos
Mechancial Fine Screen	3.0m Width X 1.5m Ht ,6 mm Opening space	60 Deg Mechanical Fine Screen	SS 304	1	Nos
Grit Chamber mechanism	6.2 m X 6.2 m X 1.4 m HT	Grit With Classifier	MSEP	2	Nos
SBR-Decanter	decanting mechanism for each tank	by hydro lifting	SS 304	4	Nos
Mixing air blower	3 nos-2w+1sb, 3500 m3/hr, 6 mwc air blowers	Tri Lobe Blower	CI	3	Nos
Submersible Mixer in Anoxic tank	2 nos , 4.5 Kw submersible mixer to be provided in Anoxic Zone	Submersible	SS 304	2	Nos
Aeration Blower	Provide 3500m3/ hr @ 0.6 kg/cm2 Capacity of air blowers 5 nos - 4w+1sb	Tri Lobe Blower	CI	5	Nos
Diffuser specifications	air supply through EPDM tubular 90mm dia x 990mm long diffusers, about 1760 numbers	Tubular membrane type	EPDM	1760	Nos
RAS pump Capacity	Provide 130 m3/ hr @ 10 mwc, horizontal centrifugal non clog pumps 5 nos - 4w+1sb	horizontal centrifugal	CI	5	Nos
SAS Pump capacity offered per tank	Provide 185 m3/ hr @ 18 m Capacity of pumps of 5 nos - 4w+1sb	horizontal centrifugal	CI	5	Nos
Filter feed pump	Provide 2100m3/ hr @ 3.5 kg/cm2 Capacity of pumps of 1 working + 1 standby	Horizontal Centrifugal	CI	2	Nos

Disc filter	Provide 2100m3/ hr Capacity of Disc Filter 50 Micron of 1 working	Disc Filter	HDPE	1	Nos
Glass Media FIlter	3.0 m Dia X 5.0m LOS with glass media High-calibrated granulometry minimum 0,4 mm. 0,7 mm. on average. 18 m3/ filter 180 m3 total for 10 filters, about 4,32,000 kgs	Horizontal	MSRL	10	Nos
Activated Carbon Filter	3.0 m Dia X 5.5m LOS; about 19.4 m3/filte x 10 nos = 194 m3 total, about 1,55,200 kgs total, Iodine value 1100, CHV max 8 cms, Calgon carbon	Horizontal	MSRL	10	Nos
Filter Backwash Pump	300 m3/h@ 25m Head	Horizontal Centrifugal	CI	3	Nos
Air Scour Blower	1000 m3/h@ 5m Head	Roots Twin Lobe Type	CI	2	Nos
Chlorine Tonner	No of 980 kg.	standard industrial tonner		5	Nos
Chlorinator	12 Kg /h	vaccum chlorinator		2	Nos
Leak absorption system	Specific system for chlorinator			1	Nos
Chlorine Booster Pump	20 m3/h@ 15m Head	Horizontal Centrifugal	CI/SS 304	2	Nos
Ozonator system including oxygen concentrator	3 kgs/hour x 4 modules	oxygen concentrator and ozone generator		4	Nos
Service water Pump	Service water for dillution & Flushing 70 m3/ hr @ 15 mwc Capacity of pumps of 1 working + 1 standby (Horizontal Centrifugal Pump type)	Horizontal Centrifugal	CI	2	Nos
THICKENER FEED PUMP	Provide 50 m3/ hr Capacity of pumps of 1 working + 1 standby (Horizontal Centrifugal type)	Horizontal Centrifugal	CI	2	Nos
SAS SLUDGE THICKNER	16.5 m Dia X 3.5 SWD	Central Shaft driven	MSEP	1	Nos

THICKENED SLUDGE TRANSFER PUMPS	Provide 10.0m3/ hr @ 15 mwc Capacity of pumps of 1 working + 1 standby (Screw Pump type)	Screw Pump	CI/SS 304	2	Nos
Centrifuge Unit	10.0 m3/h along with all accessories	Drum type	SS	2	Nos
Supernatant transfer pump:	Provide 1Nos of pumps with capacity of 50 m3/hr @ 14 m with 1 standby pumps (Horizontal Centrifugal Type)	Horizontal Centrifugal	CI/SS 304	2	Nos
POLYELECTROLYTE DOSING Tank	1 m3	Vertical	HDPE	2	Nos
AGITATOR FOR POLYELECTROLYTE DOSING Tank	1 m3	TOP MOUNTED	SS 304	2	Nos
POLY DOSING PUMP	75 LPH@ 5.0 BAR	plunger / screw pump dosing	PP	2	Nos
Safety Shower			PVC	1	No
Monorail in Blower House	1 ton			1	No
Monorail in Chlorine Tonner	1 ton			1	No
Monorail in Dewatering Building	1 ton			1	No
Interconnecting piping and valves	all piping + valves as per valve schedule			1	No

PART 12
PARTICULAR ELECTRICAL REQUIREMENTS

PARTICULAR REQUIREMENTS – ELECTRICAL EQUIPMENT

12.1 INTRODUCTION

Contractor has to do electrical work where ever specify on design, build operate and mantainence model. The specific design and performance requirement for all electrical equipment are given in this part of the Specification. The requirement specified shall be fully met with by the Contractor . In case of any deviations, the Contractor shall bring out the same in "Schedule of Deviations from Particular Requirement" failing which it will be considered that the Contractor fully complies with these requirement. General Requirement of electrical equipment is covered under Part-6 of this specification. Tender drawings will be provided for **reference purpose only**.

12.2 PRIMARY POWER SOURCE

The proposed STP facilities at Dr Shivarama Karatha Layout are at new location and the electrical power supply for this location shall be derived from the nearby Dedicated RMU which already connected to 66/11KV substation in the layout. 2 Nos. of incomers shall be derived from the output VLs of RMU dedicated for STP at Layout through 11kV underground cables by complete trench work sand and refilling. Necessary HT metering unit to be will be provided at the incomer as per BESCOM specification.

The STP Contractor's scope includes liasoning with BESCOM for getting construction power supply, making permanent new power supply agreement for the plant and getting final clearance from CEIG for complete Electrical system.

The Contractor's scope for STP starts with the proposed STP switchyard cover all equipment/items as given below the Scope of works.

12.3 POWER SUPPLY ARRANGEMENT

The power supply scheme and distribution described below is **for reference only**. The Tenderer shall prepare his own design calculations, conduct detailed engineering and prepare drawings to make his own estimate of quantities for entire electrical system.

Power Requirement

The estimated working load for STP is

STP Load = 10000 KWH/day (approx,)

Note: The power load mentioned above is for reference/indicative purpose only. Contractor shall asses the various loads required for successful commissioning & operation of the project.

Main Power Supply Scheme

12.3.1 4 Way DAS type RMU at incomer

One Nos. - 4 Way DAS type RMU, 2OD + 2VL (One Incomer + Two Breakers + One Outgoing) 630 Amps with Copper Busbar, necessary protection numerical Relays, Multi-functional meters, fault passage indicator (FPI), Metering CTs, Protection CTs, Auxiliary transformers, Potential transformer, Batteries, Battery chargers (12 V & 24 V) as per KPTCL/BESCOM specification along with mounting accessories and civil foundation to be proposed.

12.3.2 HT metering cubicle panel

One Nos. - HT metering cubicle panel with ETV meter along with measuring PTs/CTs, as per KPTCL/BESCOM specification along with mounting accessories and civil foundation to be proposed.

12.3.3 5 Way compact type RMU for transformer incomer

One Nos. - 5 Way compact type RMU, 2OD + 3VL (One Incomer + Three Breakers + One Outgoing) 630 Amps with Copper Busbar, necessary protection numerical Relays, Multi-functional meters, fault passage indicator (FPI), Metering CTs, Protection CTs, Auxiliary transformers, Potential transformer, Batteries, Battery chargers (12 V & 24 V) as per KPTCL/BESCOM specification along with mounting accessories and civil foundation to be proposed.

12.3.4 Three Nos. Power Transformer 11/0.433

Three Nos. - Power Transformer 11/0.433 suitable for complete plant load in 2W+1S configuration with all protection and subcomponent accessories resting on dedicated civil foundation - 11kV/433V Delta Star, Dyn11 - Core copper Cable entry type with Oil as per IS-1180 (Part-1): 2014 with OLTC, RTCC Panel, etc., complete filled with Transit Oil & 10% spare oil in non-returnable drum as per KPTCL/BESCOM Specification.

12.3.5 LT Distribution Main PCC Panel

One nos. LT Main PCC Switchgear Indoor type Panel which feed from 11/0.433 kV Transformers, for distribution of power supply to STP plant different sub area equipments like Grit coarse , rectifier, blower, pump house, alum chorine dosing units etc . to be proposed.

Floor mounting type LTPCC panel as per BESCOM/KPTCL specification fabricated from sheet metal and painted with provision for suitable incoming and specified number of outgoing feeder inlets with metering and protection accessories complete with mounting and foundation.

(a) 2 Nos. Incomer with ACB with accessories like PT/CT , Voltmeter, ammeter , indicating lamps , numeric relay TNC, MFM etc .

(b) Bus Coupler ACB/MCCB with all interlocks

(c) Outgoing feeder with MCCB, contactors, VFD, Softstarter, OLR relays, timer Lamps, Push buttons etc for operating the plant equipments .

Aprt that there will be Auxillary Transformer, Emergency panel , MLDB ,

12.3.6 Capacitor Panel with autocorrection power factor relay.

Auto correction type LT capacitor panel consist of load Isolator, HV fuse, series detuned reactor & capacitor unit with comprehensive protection to be provided parallel to inductive load of required KVAR as per BESCOM/KPTCL specification.

12.3.7 LT Distribution with 0.415 kV DG

0.415kV LT DG sets shall feed the emergency loads of STP through 0.415kV emergency Panel.

12.3.8 Remote/Local operating panels

In STP plant there will remote or local panel near each and every equipment for operation Grit coorse screen , Rectifier , Blower , Sump pumps etc with basic operating PB , Indicating lamp and some meter(if applicable)

12.4 GENERAL DESIGN CRITERIA FOR STP

(a) The design standards described herein are generally in compliance with the latest Indian Standards, and code of practices already established in the country.

(b) All electrical installations shall conform to the latest Indian Electricity Acts and Rules.

(c) All electrical equipment shall be rated for 45°C design ambient temperature.

(d) Explosive Atmosphere (Applicable in areas like DG etc):

(i) The following factors shall be considered for proper selection of electrical apparatus or equipment for areas where flammable gas or vapours may rise.

(ii) The classification of area shall be as per IS 5571 & IS 5572, based on the degree of probability with which explosive concentrations of combustible gas or vapour may arise in installations in terms of both the frequency of occurrence and probable duration of existence on each occasion.

- Zone 0 – In which an explosive gas/air mixture is continuously present or present for long periods.
- Zone 1 – In which an explosive gas/air mixture is likely to occur in normal operation.
- Zone 2 – In which an explosive gas/air mixture is not likely to occur in normal operation and if it occurs, it will exist only for short periods.

(iii) Gas Group Classification:

The characteristics of the gas or vapour involved in relation to Igniting current or minimum ignition energy in case of installations of intrinsically safe apparatus or maximum experimental safe gap data in case of installations for flame proof enclosures as per IS 2148.

(iv) Temperature Classification:

The Ignition temperature of the gas or vapour involved, or the lowest value of ignition temperature if more than one combustible material is present. The maximum temperature of any unprotected surface of electrical equipment shall not exceed the Ignition temperature of gas or vapour.

(v) For electrical apparatus, no margin of safety need be applied between maximum surface temperature and ignition temperature. The Ignition temperature of combustible gases and vapours are measured in accordance with the test method prescribed in IS 7820.

(vi) Environmental conditions in which the apparatus is installed. Apparatus and its component parts shall be constructed so as to guard against electrical and mechanical failures in the intended conditions of use.

(vii) The selection of type of protection of electrical equipment for the different zones of Hazardous areas shall be made in accordance to Clause 6, Table -1 of IS 5571. All electrical equipments installed in hazardous areas shall confirm to selection of equipments and installation guidelines of IS 5571.

(e) **11kV System**

a) Nominal voltage	:	11kV
b) Number of phases	:	3
c) Frequency	:	50 Hz
d) Connection	:	3 Wire
e) Maximum Fault Level	:	500 MVA
f) Fault Current	:	26.2 kA

(f) **LV System**

a) Voltage:	:	415 V nominal
b) Frequency:	:	50 Hz
c) Connection	:	4 wire
d) No load transformer voltage	:	433 V
e) System earthing	:	Solidly earthed
f) Maximum fault level	:	36 MVA
g) Fault Current	:	50 kA

Plant shall, unless otherwise specified, be capable of continuous operation at a voltage level in the range of 90% to 110% of the relevant nominal voltage and a frequency variation of ±5% with a maximum combined tolerance of 10%.

(g) **AC Control, Lighting and Space Heating**

a) Voltage:	:	240 V
b) Phases:	:	1
c) Frequency	:	50 Hz
d) Connection	:	2 wire (Phase & Neutral

(h) **DC Control, Protection and Alarm**

a) Voltage:	:	110 V
b) Phases:	:	1
c) Connection	:	2 wire (unearthed

12.5 11KV INDOOR/OUTDOOR SWITCHBOARD

(a) 11 kV switchgears / MCC shall be sheet metal enclosed with draw out type vacuum circuit breakers for incoming and outgoing feeders, control and protection for the LV motors.

(b) The switchboard shall be rated for a fault current not less than 26.2 kA (rms).

12.6 DISTRIBUTION TRANSFORMERS

(a) The transformers shall be out door type, ONAN, 11/0.433 kV, 3 phase, 50 Hz, copper winding, Delta Star, Dyn11 with solidly earthed neutral.

(b) The transformers shall be sized considering 20% contingency of total working load while arriving at the final capacity of transformers.

(c) Three nos. of transformers shall be provided such that under normal condition, two working and one standby concept.

(d) The transformer shall be designed such that at any point of time maximum loading on any single transformer shall not exceed 80% of full load capacity.

12.7 ENERGY EFFICIENT INDUCTION MOTORS

(a) Motors Rated 175kW & below shall be suitable for 415V, 3 Phase, 4 Wire, 50Hz, Solidly Earthed System.

(b) The Motors will be of Reputed and Reliable make and the same will be subject to approval of client's representative.

(c) The Degree of Protection of Terminal Boxes of all Outdoor Motors shall be IP55.

(d) All the stator winding terminals of the induction motors shall be brought out up to the terminal box.

(e) All LT motors are required to be TEFC type with class "F' insulation. Outdoor type Motor shall be with IP55 degree of protection and indoor shall be IP54. LT energy efficient motors shall be as per IS 12615 & IEEMA 19-2000 and shall have Efficiency Class equal to IE-2 as per IS 12615: 2011.

12.8 SYSTEM PROTECTION

Numerical relay based protection system for various parts of the power supply system are proposed. The following protection systems shall be used:

(a) 11 kV System

11 kV Incomer Feeder

- Inverse definite minimum time phase over current protection;
- Inverse definite minimum time earth fault protection.
- Under voltage Relay

11 kV Outgoing Feeder

- Inverse definite minimum time phase over current protection
- Inverse definite minimum time earth fault protection.

(b) 415V System

415 V Incomer Feeders

- Over current & Earth fault protection;
- Under voltage relay.

LV Motors

Motors less than 15 KW

- Overload protection by three phase thermal (bimetal) relay.
- Single phasing preventor.
- Motor Protection Circuit Breaker

Motors 15 kW up to 132kW

- Overload;
- Earth fault;
- Phase currents out of balance.
- Single phasing preventor.

Motors 132kW and above

- Comprehensive motor protection relay providing the following protection:
- Thermal Overload;
- locked rotor;
- Phase Over current (50/51);
- Earth fault (50N/51N);
- Over voltage & under voltage;
- phase loss/reversal;
- Negative sequence;
- Protection for repeated and prolonged starts;
- restart inhibition;
- Single phasing preventer;
- MCCB

(c) Pump Drives

All pumps shall be provided with the following additional protection, as per requirement:

- Dry run protection;
- Temperature protection (Submersible pumps)
- Moisture entry protection (Submersible pumps)
- Over pressure (positive displacement pumps)

(d) Blowers

Blowers shall be provided with the following additional protection:

- Over pressure

(e) Rotating Arm Drives

Rotating arm drives shall be provided with the following additional protection:

Motion detectors;

- Over torque detectors.

(f) Valve Actuator Drives

Valve actuator drives shall be provided with the following additional protection:

- Over torque detectors.

12.9 SWITCHGEAR EQUIPMENT / INSTRUMENTS

(a) 11 kV Feeders (Incomer feeders)

- Ammeter for all 3 phases;
- Voltmeter with selector switch;
- Digital Multifunction meter with RS 485 connectivity

(b) 415V Incomer Feeders

- Ammeter with selector switch
- Voltmeter with selector switch;
- KW meter;

(c) 415V Motor Starter Feeders

- Ammeter with selector switch;
- KW meters for Motor feeders more than 132 kW;
- Multifunction meters with facility to extract historical data;
- DOL Starters for motor feeders less than or equal to 5.5 kW;
- Star-Delta Starters for motor feeders above 5.5 kW and upto 132 kW;
- Line/Neutral Soft Starters for motor feeders above 132 kW;

12.10 STANDBY DIESEL GENERATOR SETS

(a) The Standby Diesel Generator Sets shall be complete with Acoustic Enclosure.

(b) The capacity and number of Standby Generator(s) shall be sized for power back up for all critical loads which are required for continuous operation of the plant and 10% Contingency over these loads shall be considered while sizing the DG Sets.

(c) In case of mains failure detected by an under-voltage relays mounted on bus of the AMF panel, the standby generator starts and after the generator set reaching the rated speed and rated voltage, the generator circuit breakers will be switched on to feed Diesel Generator power to the panel. On restoring main supply, the reverse sequence of the above will be followed for the mains supply to feed power to the loads as in normal condition. Refer section 12.12 for operation logic for mains and DG.

12.11 415 V PCC / MCC

(a) The feeder list indicated in the SLD is only tentative. The Bidder has to design the feeder configuration on the basis of equipment/load list, equipment/ load locations & 10% spare capacity for future addition. These schematics shall be submitted to employer, along with the bids.

(b) 415 V PCC/MCC shall be floor standing, sheet steel enclosed with IP 42 Degree of Protection, Form – IV or better enclosure as per IS 8623 complete with Air circuit breakers/MCCB"s/MPCBs, Control & Protection. The PCC /MCC shall be rated for a fault current not less than 50 KA (rms) for 1 sec. Outdoor panels shall be with minimum IP-42 degree of protection.

(c) All Motor Feeders in the MCC Panels shall have Contactors, Start Stop Push buttons, OLR Reset button and ON-OFF-Trip indication.

(d) All Motor Feeders in the MCC Panels shall be operated from PLC with necessary programming for SCADA software.

(e) Emergency Stop push button will be provided near the motors.

(f) All door locks shall be provided with special keys to ensure opening by authorized personnel only.

(g) Earth bus-bar shall be extended outside the switchboard at the ends.

(h) Panel height shall not be more than 2300 mm (Including 100mm base ISMC if it is pedestal mounted). The depth of panel shall not exceed 1350mm & any operating handle of switchgear shall not be more than 1800 mm and not lower than 300 mm from base of the panel.

(i) The exposed bus live parts in the cable alley shall be totally covered against accidental contact by a shroud (and not by sleeve) to protect the workmen working on the switchgear.

12.12 OPERATION LOGIC OF SWITCHGEARS

Operation Logic of 11kV Switchgear:

11 kV Main Switchgear Panel:

The one incomer- (From HT cubcile) of 11 kV Main Switchgear Panel shall be provided with independent control.

LT 0.415 kV STP MCC Panel & TSPS Panel:

Incomer(Mains of Transformer 1 & 2) & Incomer of respective DG of 0.415 kV STP MCC Panel, shall be interlocked such that Generators are closed only when Incomer-1 & 2 are open. In case, power supply is not available from mains, the same shall be provided from DG of respective transformer Bus coupler shall be closed if necessary keeping incomer 1 & 2 open.

Under normal condition, the total power required for the STP is fed from mains. In case, power supply is not available from Grid mains, the same shall be provided from respective DG.

DG Operation Logic

In case of power failure, the under voltage relay of Incomer-1 or 2 (Mains) shall give a start command to DG Sets sequentially.

12.13 POWER FACTOR

The system shall be designed such that a power factor of not less than 0.9 is maintained.

12.14 DC POWER SUPPLY

(a) 110V DC system is envisaged for protection and controls of 11kV control PLC and relay panel.

(b) DC Power supply shall be provided for Trip / Closing coils, Indications etc. of 11kV and 415V Switchgears.

(c) Local circuit breaker shall be provided for batteries.

(d) The batteries shall be 110V, maintenance free and shall be complete with battery, battery charger with boost & trickle charging facilities, necessary controls, indications and DC distribution board.

(e) The battery room shall be provided with acid proof tile flooring, corrosion proof lighting fixtures, exhaust fans and wash basin.

12.15 CABLING

a) HV Power Cables

HV cables shall be 3 core, 11kV (UG), XLPE type with stranded aluminum conductors & GI armouring. Minimum size of cable shall be selected based on the short circuit considerations.

b) LV Power Cables

LV power cables shall be 1.1 kV XLPE type with stranded aluminum conductors with GI armouring for sizes 6 sq.mm and above and stranded Copper Conductors with GI armouring for sizes below 6 sq.mm. No. of cores shall be as per requirement.

c) Control cables

Control cables shall be 650/1100V, PVC with stranded copper conductors and GI armouring. No. of cores shall be as per requirement. Minimum size of core shall be 1.5 Sq.mm.

d) Cable Rating

All power cables shall be sized for continuous current carrying capacity and permissible voltage drop at an ambient temperature of 45 ^{0}C. Due consideration shall be taken of cable grouping, method of installation and local variations in ambient conditions.

Further, for cables controlled by circuit breakers, due consideration shall be given to the fault level.

HV and LV cables shall be sized for a minimum fault clearance time of 1 second for incoming feeders, 0.5 seconds for tie feeders & and 0.16 second for equipment feeders.

For all LT Cables, the voltage drop in the cables between the transformer and the switchgear (PCC) or between PCC and MCC for full load current shall be limited to 2%. Further the voltage drop in cables between PCC/MCC to Motor terminals for full load current shall be limited to 3%. The total Voltage drop transformer secondary to motor terminal shall be limited to 5%.

Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 15%.

Cable Installations

Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. These shall be used to route cables along walls, below beams and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made while sizing the cables.

Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The Table 12.1 details the distances in mm that shall be maintained between the different categories of cable.

Table 12.1: Separation Distances in mm between different Categories of Cable

Cable Category	HV Power	LV Power	C&I/Protection	Telecom
HV Power	N/A	300	600	600
LV Power	300	N/A	300	300
C&I/Protection	600	300	N/A	100
Telecomm	600	300	100	N/A

e) Cable Numbering

All cables shall be allocated a unique number which will be fixed to each end of the cable using a corrosion resistant label. Cables of different categories will be tagged with the following subscripts and a three digit number.

- HV power HV-P
- LV power P
- Control C
- Instrumentation I
- Protection PR
- Telecommunication T

12.16 BUILDING SERVICES

a) Lighting

The lighting system work shall conform to the requirements of relevant code of practice, and drawings enclosed with specification.

All internal and external areas shall be provided with LED lighting. The illumination levels to be achieved shall be as follows:

Table 12.2: Illumination Levels

Sr. No.	Area	Min. Lux Level
1	Offices	300
2	Control Room / SCADA Room – General Lighting	300
3	Laboratory	300
4	Indoor Electrical substation, DG Room, Blower & Pump rooms	200
5	Pantry	100
6	Stores (indoor)	150
7	Toilet	100
8	Battery Room	150
9	Machinery service area	200
10	Chemical and general stores	150
11	Chemical Plant Room	200
12	Cable basement	100
13	All other indoor areas	100
14	Outdoor platforms and walk ways	50
15	Building entrance	100
16	Outdoor plant areas	20
17	Outdoor transformer yards - General - On equipment	 20 30
18	Street lighting	20
19	Emergency Lighting	
20	LED Exit sign (Wall / Ceiling)	

Emergency Lighting shall be provided with self contained chargeable type emergency luminaries in internal premises as per requirement. These luminaries shall automatically illuminate in the event of a power failure and provide a minimum level of lighting for approximately 3 hours. They shall automatically recharge on the return of mains power.

The outdoor lighting fittings shall be weatherproof, dustproof and corrosion resistant with IP 65 protection class.

The main entrance to the building, structures, all external area/ road/ pathway and site where required, shall be provided with appropriate external lighting.

For area lighting, Building structures shall be used as a support for installation of fixtures.

Outdoor/ street lighting shall be provided with photocell & timer controls, with manual override facilities.

Wiring:

i) Wiring for lighting in office & pumping station internal areas will be done with 1.1kV, PVC insulated, stranded copper conductor wires of area not less than 2.5 sq mm in concealed conduits.

ii) Lighting in external areas shall be installed using multicore armored cable.

b) Ventilation Fans

Variable speed ventilation ceiling fans & exhaust fans shall be provided in offices and switchgear rooms as per requirement. One Ceiling fan of 48" size shall be provided for each 10 Sq.mtrs or part thereof of the area concerned. The supply to these fitted ceiling fans shall be provided from the local lighting circuit.

c) Small Power Outlets

Switched single phase three pin 6 A and 16A receptacles shall be provided throughout. In offices and control rooms they shall be modular decorative type and industrial type in all other areas for single and three phase sockets. All outlets for domestic pump, dewatering pump, submersible sump pump shall be provided with local starter panel or control cubicle. All metal clad sockets shall be provided with suitable metal clad plug. All socket outlets shall be provided with ELCB/RCCB at the source side.

Unless required to be provided in greater numbers to power specific Plant items the number of such outlets shall be as follows:

- 6 A type one outlet per 5 m or part thereof of perimeter in offices and laboratories;
- 6 A type one outlet per 20 m or part thereof of perimeter in all other areas;
- 16 A type one outlet per 20 m or part thereof of perimeter in offices and laboratories;
- 16 A type one outlet per 20 m or part thereof of perimeter in all other areas.

30 A switched (MCB) three phase and neutral receptacles shall be provided in plant areas where appropriate i.e. adjacent to areas where flooding is likely (to permit the use of portable sump pumps) or where other portable equipment is likely to be used in the operation of the treatment plant. The Contractor shall install ten such outlets at various locations throughout the treatment plant.

The location of outlets shall be approved by the Engineer. The spacing of 6A and 16A outlets shall be arranged to suit the intended location of equipment, desks etc. Receptacles for outside areas shall have a degree of protection of IP 55.

12.17 EARTHING & LIGHTNING PROTECTION

(a) An earthing system comprising earth electrodes and conductors shall be established for Sewage Treatment Plant.

(b) The earthing system will be designed to give a combined earth resistance value of not greater than 1 ohm. In order to be sure of obtaining suitable final values, soil resistivity shall be measured at the various sites during the detailed design phase of the work.

(c) In outdoor substation areas the main earth electrode conductors shall be located, to ensure potential gradients occurring at the surface during fault conditions are kept within allowable limits.

(d) Materials used for earth electrodes shall be designed to suit the ground conditions and shall either be plain mild steel or Galvanised steel.

(e) The system shall be designed for the following maximum earth fault currents. These values will be confirmed at the detailed design phase.

- 11 kV system 26.2 kA.
- 415 V system 50 kA.

(f) The fault clearing time shall be taken as one second for the 11kV and 415 V systems.

(g) The maximum temperature allowed for steel welded joints will be taken as 500 ^{0}C with an ambient of 45^{0}C. Main equipotential bonding conductors shall be galvanised steel.

(h) Circuit protective conductors will comprise either the armouring of the supply cable or, for major loads such as main switchboards and large drives the supply cabling plus an additional suitably sized single core copper cable.

(i) The neutral point of the 11/0.433 kV transformer secondary windings shall be solidly earthed.

(j) Lightning protection system shall be provided on all main structures. Air terminations and down conductors shall be copper.

(k) The lightning protection system needed shall be established by calculating the risk factor value of each building, structure etc as per procedure given in IS/IEC: 62305.

(l) The lightning protection installation shall comply with Standard Specifications.

(m) Air termination system comprising of rods/mesh or combination of both shall be provided and the methods used to determine the positioning of Air Termination system shall be as per IS/IEC 62305.

(n) Air termination system shall be connected to the earthing system by down conductors fixed along the outer surface of building. Number & layout of the down conductors shall be as per IS/IEC 62305.

(o) Each down comer shall be terminated to a separate treated test earth electrode which in turn will be connected to the station earthing system.

(p) Test link shall be provided in the run of each down conductor at approximately 1000 mm above ground level.

12.18 FIRE ALARM & PROTECTION SYSTEM

(a) Fire Alarm system shall be designed to provide continuous surveillance against fire in the areas covered by the system under all conditions.

(b) Fire alarm system shall be capable of notification of fire alarm, supervisory and trouble condition and to control fire safety functions. The design requirements are defined as part of design engineering, fire alarm scheme based on requirements of NFPA 72, National Fire Alarm Code (2002 edition).

(c) The Fire alarm control panel, detectors and other related devices used in the system shall conform to international Standards UL/ LPCB/ FM.

(d) The following annunciation but not to limited to these shall be available in the control room

- Fire on the transformer
- Fire/fault in particular Zone

(e) Manual call point of outdoor type shall be provided on each gate of switchyard and inside the switchyard shall be such that no person inside the switchyard has to travel more than 30m to 40m to raise the alarm.

(f) Fire fighting system shall contain but not to limited to, the items listed below –

- Portable fire extinguishers
- Nitrogen injection fire prevention method for transformer
- Sand & Water Bucket

12.19 TECHNICAL DATA SHEETS

12.19.1 11 KV/ 0.433 kV Distribution Transformers

Sr. No.	Description	Unit	Technical Particulars
1	Rated output	KVA	As per the Requirement
2	Quantity required	Nos.	As per the Requirement
3	Transformer location		Outdoor
4	No load transformer ratio	kV	0.433
5	Number of phases		Three
6	Rated frequency	Hz	50
7	Impedance at all taps	%	Value as per IS 2026
8	Number of winding/ material of conductor		Two/Copper
9 (a)	Method of connection HV winding		Delta
(b)	LV winding		Star
10	Vector group		Dyn 11
11	LV Neutral		Solidly earthed
12	Type of cooling		ONAN
13	Reference Ambient	^0C	45
14	Oil by thermometer	^0C	40
15	Winding by resistance	^0C	45
13	Tap changer		As per Specification
14	Tap range	%	As per Specification
15	Tap step	%	As per Specification
16 (a)	Terminal connection HV terminals		Cable box with air insulated disconnecting Chamber
(b)	LV terminals		Suitable for connecting Bus Duct emanating from top side of transformer with neutral 100% rated
17 (a)	Current Transformer On LV		As per Requirement
(b)	On LV Neutral		
18	LV Neutral earthing		LV neutral bushing – part of bus duct as well as separate neutral bushing For earthing connection.
19	Insulation of Windings		H.V. L.V.

Sr. No.	Description	Unit	Technical Particulars	
(a)	One minute power frequency withstand voltage (dry and wet)	kV (r.m.s)	28	3.0
(b)	1.2/50 micro second full wave impulse withstand voltage	kV (peak)	75	
20	Insulation of bushings		H.V.	L.V. (Line and Neutral)
(a)	Rated Voltage of bushing	kV	12	1.1
(b)	Power frequency withstand voltage	kV (r.m.s)	28	3.0
(c)	1.2/50 microsecond full wave impulse withstand voltage	kV (peak)	75	-
(d)	Minimum Creepage distance	mm	25mm/kV 12kV	25mm/kV on 1.1kV
21	Vacuum withstand capability of transformer main tank with bushings, radiations, fitting and accessories.		Upto 200kVA - 250mm of mercury Above 200 kVA – 500mm of mercury	
22	**11 kV Cable Box** 11 cable box shall be provided on transformer towards right hand side of transformer with when viewed from H.V side. This will facilitate removal of transformer for maintenance without affecting 11 kV cable terminations.			
23	**Radiator Banks** Radiator banks shall be provided on transformer on left side when viewed from H.V side.			

12.19.2 11 kV Metal Enclosed Switchgears/ MCC

Sr. No.	Description	Unit	Technical Particulars
1	Quantity	No.	As per Requirement
2	**Switchgear cubicles and Busbar ratings**		
(a)	Rated voltage, phases and frequency		11 kV, 3 Ph 50 Hz
(b)	System Neutral Earthing Effectively earthed / Non effectively earthed		Non-effectively earthed. Resistance earthed limiting earth fault current to full load current
(c)	Maximum system voltage	kV	12
(d)	ower frequency withstand voltage	kV (rms)	28
(e)	12/50 sec impulse withstand voltage	kV (peak)	75
	Short circuit withstand (i) Short time (1 sec) at rated voltage		26.2
	(ii) Dynamic rating		62.5
(g)	Reference ambient temperature		45°C
(h)	Maximum temperature of bus bars droppers connectors and contacts at continuous current rating under site reference ambient temperature		90^0C - FOR BUSBARS HAVING NON-SILVER PLATED JOINTS 105^0C - FOR BUSBARS HAVING SILVER PLATED JOINTS
(i)	Continuous current rating of bus bar	A	As per the SLD
(j)	Bus bar material		Copper
(k)	Bus bar Insulation		Fully insulated by encapsulation in epoxy resin with mould caps protecting all joints
(l)	Cable entry		Bottom
	Cable type for Incoming and Outgoing feeders		11 kV XLPE unearthed Aluminium conductor
3	**Switchgear constructional Requirement**		
(a)	Thickness of sheet steel Frame, Frame enclosures, doors, covers and partitions	mm	Frame – 2.5 Doors/Covers – 2.0
(b)	Degree of protection		BUS BARS – IP3X, OTHERS – IP4X
(c)	Colour finish shade		Interior - GLOSSY WHITE Exterior - Light grey semi-glossy shade 631 of IS:S
(d)	Earthing bus i) Material		Copper

Sr. No.	Description		Unit	Technical Particulars
		ii) Size	mm x mm	25 x 6 (*)
(e)	Earthing conductor	i) Material		GS Flat
		ii) Size	mm x mm	50 x 10 (*)
4	**Breaker Particulars**			
(a)	Circuit breaker type			Vacuum (With Surge Suppressor)
(b)	Voltage, phases and frequency			12 kV, 50 Hz, 3 Ph
(c)	Rated operating duty			O-3 MIN-CO-3 MIN-CO
(d)	Rated current at reference ambient temperature Incoming breakers		A	As per the Requirement
	Outgoing breakers		A	As per the Requirement
(e)	Rated breaking capacity		kA (rms)	26.2
(f)	Rated making current		kA (peak)	62.5
(g)	Short time current withstand for 1 sec duration		kA (rms)	26.2
(h)	Total break time			Less than 5 cycles
(i)	Operating mechanism type (Normal)			Motor Charged Spring.
	Operating mechanism type (Emergency)			Manual Spring Charged for closing and tripping
(j)	Minimum no. of auxiliary contacts			6 NO+ 6 NC
(k)	Withstand test voltage (i) One minute power frequency		kV (rms)	28
(l)	(ii) 1.2/50 □ sec impulse		kV (peak)	75
	Auxiliary control voltage (i) For closing / tripping coil			110 V DC
	(ii) For spring charging motor			240 V AC
(m	(iii) For space heaters and lighting			240 V AC
	Anti pumping feature			To be provided

Sr. No.	Description	Unit	Technical Particulars
(n)	Latching requirement		Trip free
	Current Transformers		
(a)	Type		Cast resin Bar Primary
	Class of insulation		Class B or better
(b)	Rated current ratio and burden		
(c)	(i) Incomers and bus couplers		As per the Requirement
	(ii) Outgoing feeders Motor feeders – Protection		As per the Requirement
	(iii) Motor feeders – Metering		As per the Requirement
	(iv) Auxiliary Transformer feeder – Metering		As per the Requirement
	(v) STP feeders – protection		As per the Requirement
	(vi) STP feeders – Metering		As per the Requirement
(d)	Accuracy class (i) Metering		MIN. CL 0.5/1.0
	(ii) Protection		MIN. 5P10
(e)	Short time 1 sec current rating	kA (rms)	26.2
(f)	Dynamic rating	kA (peak)	62.5
6	**Voltage Transformers**		
(a)	Type		Cast resin
(b)	Rated Voltage (i) Primary	V	11000/√3
	(ii) Secondary – S1	V	110/√3
(c)	Method of connection (i) Primary – P		Star, earthed
	(ii) Secondary – S1		Star, earthed
(d)	Application – S1		Metering and protection
(e)	Rated burden	VA	As per the Requirement (should be capable to supply the whole panel if the PT on the other side of bus coupler not working)
(f)	Accuracy class		Class B or better
(g)	Rated voltage factor (i) Continuous		1.1
	(ii) Short time		1.5
7 (a)	Meters Accuracy Class (i) Indicating Meters		Digital/Analogue Class 1.0 or better
	(ii) Energy Meter		Class 1.0 or better
8	**Annunciations**		
	Following alarm annunciation shall be provided on the respective 11 kV switchgear modules		
(a)	Incoming feeders Incoming circuit breaker - trip Lockout relay - trip (iii) Bus section circuit breaker trip		

Sr. No.	Description		Unit	Technical Particulars
(b)	Outgoing feeders (motor feeders) Motor trip on fault Motor winding temperature high alarm Motor winding temperature high trip			
(c)	Other Outgoing feeder - trip			
(d)	Spare windows	As per SLDs		
9	**Cubicle Components**			
	Each 11 kV circuit breaker cubicle shall be provided with the following minimum standard accessories			
(a)	One control switch "trip-neutral-close" spring return to neutral position			
(b)	One control selector switch "Local-remote stay-put" type			
(c)	Indicating lamps with series resistors			
	(i)	"Red" for breaker in "On" indication (this shall also supervise trip coil)		
	(ii)	"Green" for breaker "Off" position		
	(iii)	"Blue" for breaker in "Service" position		
	(iv)	"Amber" for breaker in "Test" position		
	(v)	"White" for breaker closing spring "Charged"		
	Indicating lamps (iii), (iv) and (v) shall be provided when positive mechanical indicators for these conditions are not available/visible			
(d)	Mechanical trip push button to trip the breaker when control supply is lost. The push button shall be shrouded type			

415 V Metal Enclosed Switchgears/ MCC

Sr. No	Description		Unit	Technical Particulars
1	**Quantity**		Nos	As per Requirement
2	**415 V Switchgear And Busbar Ratings**			
(a)	Rated voltage phase and frequency			415 V, 3 Ph 50 Hz
(b)	System Neutral Earthing			Effectively earthed
(c)	Maximum system voltage		V	476
(d)	One minute power frequency voltage i) Power circuits		V	2500
	ii) Control circuits		V	1500
	iii) Aux. Circuits connected to Sec of CTS		V	2000
(e)	Continuous current rating of Busbars under site reference Ambient Temperature and type & material		Rating Material	As per the Requirement, Copper
(f)	Busbar insulation			Fully insulated encapsulation in epoxy resin with moulded caps protecting all joints
(g)	Reference Ambient Temperature		° C	45
(h)	Maximum Temperature of Busbars, Droppers and Contacts at current rating under site ambient temperature			85° C for bus bars and non silver plated joints 100° C for silver plated joints
(i)	Short Circuit current withstand for Busbars and droppers (i) Short time 1 sec		kA (rms)	As per SLD & specs 50kA
	(ii) Dynamic Rating		kA (peak)	125kA
3	**Switchgear Constructional Requirement**			
(a)	Type of Construction			Single front fixed type
(b)	Thickness of sheet steel (i) Frame, Frame enclosures, doors, covers and partitions		mm	Cold Rolled – 2.0
(c)	Degree of protection			AS PER IS:13947
(d)	Colour finish shade			Interior : Glossy white Exterior : Light grey semi glossy Shade 631 of IS-5
(e)	Earthing bus	Material		Copper
		Size	mm x mm	25x6 (*)
	Earthing conductor	Material		GS
(g)		Size	mm x mm	50 x 10 (*)
	Minimum clearances in air of live parts (i) Phase to Phase		mm	25.4
	(ii) Phase to Earth		mm	19.4

Sr. No	Description	Unit	Technical Particulars
(h)	Cable entry to cubicles		Bottom
4	**Starters**		
(a)	Contactor rated duty		AS PER IS:13947
(b)	Utilisation category		AS PER IS:13947
(c)	Control transformer :		
(d)	Standard applicable		As per Specifications
(e)	Thermal over load relay reset		
5	**Circuit Breakers**		
(a)	Circuit breaker type		Air circuit Breaker
(b)	Voltage, frequency & no. Of phases		415V, 3 PHASE, 4W,50Hz
(c)	Rated breaking duty		B-0.3 SEC-MB-3 SEC-MB
(d)	Rated breaking capacity MVA KA(RMS) at 415V 0.25 p.f.		
(e)	Short circuit withstand current for 1 sec. Duration	kA (RMS)	50
(f)	Rated making current	kA(PEAK	125
(g)	Type Of Operating Mechanism		Motor wound spring charged
(h)	Minimum No Of Auxiliary Contacts		6 NO + 6 NC
(i)	Standards Applicable		As per specs
6	**MCCB's**		
(a)	Moulded case circuit breakers to be provided. (a) for motor control circuits (b) for other circuits		
(b)	Voltage, frequency & no of Phases		415V, 50Hz, 3PH
(c)	Rated operating duty		O-3MIN-CO-3MIN-CO
(d)	Rated breaking capacity (at 415v 0.25 p.f.)	kA(RMS)	50
(e)	Rated making current	kA (Peak)	125
(f)	Rated current at site reference ambient temperature		As per Specifications
(g)	On/off operation Manual Remote power operated		Yes Yes
(h)	Releases required Over load inverse time Under voltage		Yes Yes
(i)	Standards applicable		As per Specifications
7	**Instrumentation Transformers**		
(a)	Current transformer (i) Ratio		As per the Requirement
	(ii) Burden	VA	As per the Requirement
	(iii) Accuracy Class		1.0
(b)	Voltage transformer (i) Ratio		(415V √3) (110V √3)
	(ii) Burden	VA	50
	(iii) Accuracy Class		1.0

415 V Power Capacitor and Control Panel

Sr. No	Description		Unit	Technical Particulars
1	**General**			
(a)	Quantity			
(b)	Rated Capacity		KVAR	As per the Requirement
(c)	Rated voltage		V	433
(d)	Rated frequency and phases			50 Hz, 3 Phase
(e)	Ambient temperature		° C	45
(f)	Cable gland required			Yes
(g)	Type of cable			1.1 kV, XLPE, Al. Conductor
(h)	Size of cable			As per Requirement
(i)	Cable entry			Bottom
2	**Constructional Requirement**			
(a)	Thickness of sheet steel i) Frame, Frame enclosures, doors covers and partition		Mm	Cold rolled 2.0
(b)	Degree of protection			IP 54
(c)	Colour finish shade			Interior : Glossy white
				Exterior : Light Grey Semi Glossy Shade 631 of IS 5
(d)	Earthing bus	Material		Copper
		Size	mm x mm	25x6 (*)
(e)	Earthing conductor	Material		Copper
		Size	mm x mm	40 x 6 mm (*)
3	**Design Requirement**			
(a)	Insulation level		kV (rms)	2.5
(b)	Capacitor bank connection			Delta
(c)	Short circuit withstand for busbars i) Short time (1 sec)		kA (rms)	As per SLD & specifications
	ii) Dynamic		kA (peak)	87.5
(d)	Type of switching			Automatic switching responsive to power factor through power factor sensing relay
(e)	Switching steps			Minimum 8 steps
(f)	Rating of contactor			To suit KVAR unit
(g)	Incomer switch current rating			To suit rated capacity of KVAR
(h)	Busbars			Copper

Battery

Sr. No.	Description	Unit	Technical Particulars
1	Application		Control, annunciation and emergency lights
2	Type of battery		VRLA
3	Number of battery banks required		As per requirement (*)
4	Ambient conditions		Min. Temp. 25° C
			Max. Temp 45° C
5	D.C. system voltage	V	110

6	Ampere hour capacity of battery at 27 Deg. C at 10 hour rate to give final cell voltage of 1.75 volts/cell	Ah	As per the Requirement
7	Momentary load/duration	A	
8	Emergency load/duration	A	
9	Continuous load/duration	A	
10	Cell voltage - initial/final	V	
11	Mounting arrangement		Multi tier
12	Charging method proposed		Float cum boost charging

Battery Charger and D.C. Distribution Board

Sr. No.	Description	Unit	Technical Particulars
1	**General**		
(a)	Number required (i) Battery charger	Nos.	As per the Requirement
	(ii) D.C. Distribution board	Nos.	As per the Requirement
(b)	DC System Voltage (Nominal)	V	110
(c)	DC System Earthing		Unearthed
(d)	Ambient Design Temperature	Deg. C	45 C
(e)	Busbar material & size	-	Copper , size as per Requirement
2	**DC Bus Load**		
(a)	Total continuous DC load	A	As per the Requirement
(b)	Short time loads (Additional to continuous loads)		
	(i) DC lights/Facia lamps	A	As per the Requirement
	(ii) Starting current and duration	A	As per the Requirement
	of Largest Connected DC Motor	Secs	As per the Requirement
3	**Battery Details**		
(a)	Float/Trickle charging current of battery	mA	200
(b)	Boost Charging Current of Battery (Maximum)	A	10
(c)	Boost Charging Voltage of Battery (maximum)	V	142
(d)	Maximum Time for Boost charging of Battery	hr	10
(e)	Battery capacity & no. of cells	Ah	As per the Requirement
		Nos.	As per the Requirement
4	**AC System Data**		
(a)	Supply Voltage	V	415
	Phase		3
(b)	(i) Variation in supply Voltage	%	± 10
	(ii) Variation in supply frequency	%	± 5
(c)	Short Circuit level	kA	35
(d)	Type of earthing		Solidly Earthed
5	**Performance**		
(a)	DC voltage setting adjustment for float charger		±10% of nominal voltage
(b)	Voltage stabilisation for constant		±1% of set D.C. voltage, with AC

Sr. No.	Description		Unit	Technical Particulars
	voltage regulator			input variation and DC load variation from 0 to 100%
(c)	Maximum permissible variation in DC voltage (no load to full load)			± 1%
(d)	D.C. voltage setting adjustment for boost charging			70% to 100% of max. boost charging voltage
(e)	D.C. current adjustment for boost Charging			30% to 100% of max. boost charging current
(f)	Current stabilisation for constant current regulator for boost charger			± 2%
(g)	Minimum permissible power factor to rated continuous load			0.8
(h)	Permissible ripple content at rated continuous load			3% (maximum)
6	**Miscellaneous**			
(a)	Constructional Features for Battery Charger & D.C. Distribution Board			
	(i) Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition		mm	Cold rolled 2.0
	(ii) Degree of protection			IP 42
	(iii) Colour finish shade			Interior: Glossy white
				Exterior: Light Grey Semi Glossy Shade 631 of IS 5
	(iv) Earthing bus	Material		Copper
		Size	mm x mm	25 x 6(*)
	(v) Earthing conductor	Material		GS
		Size	mm x mm	40 x 6(*)
(b)	Cable entry			Bottom
(c)	Cable Sizes (i) Battery		sq.mm	As per the Requirement
	(ii) DC output		sq.mm	As per the Requirement
	(iii) AC input		sq.mm	As per the Requirement
(d)	Relay for auto changeover from Float to boost mode to be provided (in case of float-cum-boost charger)			Yes

Cables: HV, LV, Control and Telecommunication

Sr. No.	Description	Unit	Technical Particulars
	11 kV earthed Aluminium Conductor XLPE, armoured power cable		As per IS 7098
	650/1100 V grade PVC insulated Aluminium conductor armoured power cable (AYWY or AYFY)		As per IS 1554

	650/1100 V grade XLPE insulated Aluminium		As per IS 7098
	conductor armoured power cable		
	650/1100 V grade PVC insulated copper conductor		As per IS 1554
	Telecommunication cables		As per IS 10579
	Epoxy Heat Shrinkable Straight through joints and end terminations.		

Lighting Fixtures and Accessories

1	**General**		LED Lighting
	Normal Supply Voltage, Phase and Frequency	AC DC	230V, 1PH, 50Hz
	Variation in Supply		
	i) Voltage	%	+10%
	ii) Frequency	%	+5%
	iii)Combined voltage & frequency	%	+10%
	Design Ambient Air Temperature	ºC	45
	Luminaire Terminal Suitable for		
2	Indoor non hazardous area		
	Conductor material		COPPER
	Wire size	Cores x s	4C x 2.5 Sq.mm
1.4.2	Indoor hazardous / Outdoor area		
	Conductor material		ALUMINIUM
	Cable size	Cores x sq.	4C x 16 Sq.mm
1.5	Luminaire Earthing Terminal Suitable for		
	a) Conductor material		GI
	b) Conductor size	SWG	12

Lighting System and Equipment

Sr. No.	Description	Unit	Technical particulars
1	**System particular**		
(a)	**Voltage**		
(i)	3 phase, 4 wire 50 HZ System		
	Rated	V	415
	Maximum	V	476
	One minute withstand Voltage		2000V
(ii)	D.C. System		
	Rated	V	110
(b)	System short-circuit level		
(i)	at 415 V, A.C.	KA (rms)	10
(ii)	at 110 V.D.C	KA (D.C)	6
(c)	Reference ambient temperature	^{0} C	45
2	**Distribution board/panels**		
(a)	Main, floor mounted distribution boards		As per the Requirement

Sr. No.	Description	Unit	Technical particulars
(i)	Main lighting distribution board(A.C)		As per the Requirement
	Make		As per Specifications
	Type		As per Specifications
	Degree of protection		As per Specifications
	Bus bar material		Copper
	Bus bar current rating	A	
	Short circuit current rating	KA	
	Details of incoming and outgoing feeders		
	Cable entry		Bottom
	Location		Indoor
(ii)	Emergency lighting panel (DC)		As per the Requirement
	Make		As per Specifications
	Type		As per Specifications
	Degree of protection		As per Specifications
	Bus bar material		Copper
	Bus bar current rating	A	As per the Requirement
	Short circuit current rating	KA	
	Details of incoming and outgoing feeders		
	Cable entry		Bottom
	Location		Indoor
(iii)	Single/three phase DBs, wall/structure mounting		
	SLDB/TLDB for indoor area		As per the Requirement
	Make		As per Specifications
	Type		As per Specifications
	Details of incoming and outgoing feeders		
	Degree of protection		As per Specifications
(iv)	Single/three phase DBs for outdoor area		As per the Requirement
	Make		As per Specifications
	Type		As per Specifications
	Details of incoming and Outgoing feeders		
	Degree of protection		As per Specifications
(v)	Paint finish		
	Colour shade:		Interior : Glossy white Exterior: Light gray semi glossy shade 631 of IS:5
3 (a)	**Street light poles and flood light poles** Street light pole		
	Type		
	Total height:	M	
	Quantity:	Nos.	As per the Requirement
(B)	Floodlight light pole		
	Type		

Sr. No.	Description	Unit	Technical particulars
	Total height :	M	
	Quantity:	Nos.	As per the Requirement
	No. Of floodlights to be fixed per pole	No.	

Lighting system Installation Work

Sr. No.	Description	Unit	Technical Particulars
1	**Installation of Earthing Conductor**		
(a)	Indoor Areas		
	(i) Size	-	SWG 12 (*)
	(ii) Material		G.S. wire
(b)	Outdoor Areas		
	(i) Size	-	SWG 12(*)
	(ii) Material		G.S. wire
2	**Installation of Conduits**		
(a)	Rigid		
	(i) Material		Galvanised steel
	(ii) Sizes	mm^2	20(*)
3	**Installation of Wires/Cables**		
(a)	1100 V, 1 Core, PVC Insulated Wires		
	(i) Conductor material		Copper
	(ii) Size	sq.mm	Lighting 1Cx1.5(*) Receptacles 1Cx2.5(*)
	(iii) Colour Coded "Black"	Metres	
	(iv) Colour Coded "White"	Metres	
(b)	1100 V, PVC Insulated PVC Sheathed Armoured Cable		
(c)	Size & cores	Core x mm^2	2/C X 4 and 2/C X 6
			ii) 4/C X 6
4	Contractor shall route and supply these items as required.		
5	Supply of earthing conductors, mounting accessories and all fixing hardware are included as part of the installation work.		
6	Supply of conduits and wires/cables and all fixing hardware are included as a part of installation work.		

Earthing and Lightning Protection System

Sr. No.	Description	Technical particulars		
		Size	**Material**	**No. of Leads & quantity**
1	**Main earthing grid**		As per Specifications and quantity as per requirement	
(a)	Buried in earth			
(b)	Buried in floor slabs in buildings			
2	**Conductor leads to equipment** (above ground)			
(a)	Transformers			
(i)	Transformer neutral to bottom of tank			
(ii)	From bottom of tank to earth grid			
(iii)	Transformer tanks and radiator bank			
(b)	Diesel & Bio Gas generator set			
(i)	Neutral earthing			
(ii)	Body earthing			
(c)	Fence posts and gates (flex. braid)			
3	11 KV metal enclosed switchboard, 415V switchgear/ MCC.			
4	**Motors**			
(a)	415V motors above 10 KW			
(b)	415V motors up to 10 KW			
(c)	Fractional Horse Power motors			
5	**Other items**			
(a)	Capacitor panel, battery charger panel, dc distribution board , Main Lighting DB, control panels and sub-lighting distribution boards etc			
(b)	Hand rails			
(c)	Cable trays			
(d)	Tanks			
(e)	Junction boxes		As per specifications	
(f)	Lighting fixtures, receptacles, lighting conduits		As per specifications	
(g)	Push button stations, limit switches			
6	**Crane rail**			
7	Street lighting, flood lighting poles and junctions boxes			
8	Metallic noncurrent carrying structures			
9	**Lightning conductors**			
(a)	Lightning protection down comers for building			
(b)	Lightning protection horizontal roof conductor for			

Sr. No.	Description	Technical particulars	
	building		
10	**Electrodes**		
(a)	Pipe/Rod Electrode		
(b)	Plate Electrode		As per specifications

Control & Relay Panel

Sr. No.	Description		Technical Particulars
(a)	Control / Relay panel designation		
(b)	Type : Simplex / Duplex /Mosaic/Panel cum Desk		Simplex
(c)	Cold rolled sheet steel thickness		Frame – 3 mm thick
(d)	Front and rear Sides, top and bottom		3 mm (min.) 2 mm for sides, 3 mm thick Gland plates
(e)	Painting Finish Enamel/Epoxy Colour Shade to IS 5.		RAL 7032
(f)	Cable Entry - Top / Bottom		Bottom
(g)	Mimic Bus colour (If required) for different voltages.		Screw on type painted aluminum strip of 12 mm x 3 mm thick
(h)	Earth bus material and size, inside the panel.		25 mm x 3 mm tinned Copper (minimum)
(i)	Degree of protection		IP 54
(j)	Auxiliary voltages to panels AC DC		240 V AC 1 phase 110 V DC (dual feed)

Note:
Any requirement/ features/ provisions not specifically mentioned in the Specification, but are necessary
for trouble free and smooth operation of the Plant System shall be included.

(*) – The numbers, ratings, sizes etc. have to be worked out by the contractor during execution and to be approved by the Engineer.

End of Part-12

PART 13

PARTICULAR REQUIREMENTS

INSTRUMENTATION & CONTROL

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PART 13

PARTICULAR REQUIREMENTS
INSTRUMENTATION & CONTROL

13.1 Instrumentation System

This section outlines the particular requirements for the instrumentation systems. Unless specified in this section to the contrary instrumentation Plant provided by the Contractor and workmanship shall comply with the General Chapters of these Requirements.

The scope of instrumentation, control and automation (ICA) works for **Sewage Treatment Plant** under this contract shall comprise of the design, manufacture, programming and configuration, off site testing, delivery to site, installation and erection, testing, commissioning, setting to work and provision of documentation for a complete instrumentation, control and automation IC&A and SCADA system including the interfaces required to provide monitoring and control for a safe and efficient operation of the STP's. The scope shall also include:

1. Process is Fully Auto-Mode through STP Control System.
2. Complete operational data of the STP's to be transmitted to the Central SCADA Monitoring Centre (CSMC) via redundant GPRS wireless gateway.

The minimum scope of work for ICA at STP's (as per attached P&ID) shall include but not limited to:

STP:

- Design, supply, install, test and commission a dual redundant PLC based SCADA system for STP. The system shall include but not limited to process controller including its central process units (CPUs), communication modules, Simplex input-output (I/O) modules(Hot swappable), control networks, operator workstations, engineering workstation and printers;
- Design, supply, install, test and commission field instrumentation for the Entire STP;
- Design, supply, install, test and commission chlorination system including its instrumentation and chlorination control units and its interface with STP SCADA;
- Design, supply, install, test and commission blower control system including its instrumentation and control units and its interface with STP SCADA;
- Design, supply, install, test and commission uninterrupted power supply system to supply the entire PLC based SCADA system including the Remote I/O (RIO) systems;
- Design, supply, install, test and commission Interface equipment to enable communication between STP and Central SCADA Monitoring Centre (CSMC) shall be located may be at BDA Kumara park west Bangalore or at Central Administrative Building at Sector 1 of DSKL
- Control room furniture include but not limited to system consoles for placing servers, workstations and printer compartments, desks for engineering workstation and printer compartment and chairs.

The Contractor shall be responsible for the design of each instrumentation and plant monitoring system, including the selection and design of appropriate transducers, transmitters, signal conditioning devices, indicators, alarm system programmable devices, communications, cable system etc. The Contractor shall take account in his design of all installation and environmental conditions prevailing at the site.

13.2 Field Instrumentation and Control

Each field instrument shall be operable in local mode and have display functions in SCADA. The Contractor shall be responsible for providing the appropriate signals at the locations required to provide the specified control and monitoring functions.

The Contractor shall ensure that field measuring systems shall respond quickly to any changes of the measured process variables.

All field instruments shall, as far as practicable, be mounted in a location that shall be free of vibration and shall be powered from the instrument control system.

24V dc power wiring for field instruments shall be individually fused and provided with a means of disconnecting the power without disturbing terminated wiring (e.g. knife-switch-type terminal blocks). Visual indication of a blown fuse condition shall be provided.

All field instrument components shall be of a proven and reliable design and shall have a high degree of uniformity and shall, wherever possible, be interchangeable. The design shall facilitate easy maintenance and repair, taking into account the availability of access routes through plant and structures generally.

Field Instruments shall perform sensing, indicating, transmitting and controlling. The devices shall generally interface with the SCADA, either directly or indirectly. The materials of those parts of the field instruments, including piping material, which are exposed to the measured media shall be compatible with the conditions of the respective media and of the ambient fluid and atmospheric conditions.

All field instruments shall be mounted within enclosures that are corrosion proof, dustproof and waterproof to provide a minimum protection specified in elsewhere in this Specification.

All field instruments, including the components, shall be tropicalised and designed for the ambient conditions detailed elsewhere in this Specification. Lighting protection barriers shall be used for protecting transmitters and receiving instruments from the surge voltage due to lighting strike. Lighting protection barriers shall be supplied at both receiving and sending ends for all signals from outside building and those installed between the buildings.

13.3 Instrumentation Design Criteria

The design criteria to be applied to instrumentation systems shall be as follows:

- all instruments shall be suitable for continuous operation;
- all transmitting instruments shall have a 4 - 20 mA linear output;
- all digital outputs shall be volt free;
- all instruments shall be designed for the ambient conditions of temperature and humidity;
- all wetted parts of instruments sensors shall be non-corrosive and suitable for use with sewage;
- all instrumentation systems for use out of doors shall be protected to IP 65;
- all analogue displays shall be of the digital type with no moving parts utilising back lit liquid crystal diode LCD / LED technology;
- instrumentation shall utilise solid state electronic technology and avoid the use where practical of any moving parts;
- minimum maintenance requirement;
- instrumentation shall resume operation automatically on the application of power following a power failure.
- All analytical instruments shall be single channel and have individual analyzer units.

Digital systems shall be provided as detailed in the Employer's Requirements and as necessary for the efficient and safe operation of the treatment plant

The Contractor shall provide Plant to measure any other parameter required for the efficient and safe operation of the treatment plant.

Instrumentation sensors shall be suitable for the environment in which they are expected to work. Sensor located in hazardous (flammable) or potentially hazardous atmospheres shall be certified for use in these areas. Sensors should be of self-cleaning type.

Instrumentation converter units shall where practical be located in the associated MCC common control panel well away from any injurious effects of the process.

13.4 Flow Measurement and Control

The Contractor shall use electromagnetic flow meters (for Sewerage Fluids/Minimum Fluid Conductivity is recommended by the manufacturer for the measurement of Sewage Flow by using Faraday's law of Electromagnetic Principle), Inline Two-Path Ultrasonic flow meters(for Air /Gas Flow Measurements) or as approved by the employers representative as the standard flow meters under this contract. Each flow meter shall be installed in the pipeline within a suitable access chamber. The access chamber shall be designed to provide adequate space for personnel access to the chamber and around the flow meter for maintenance. The flow meter system shall provide flow rate and totalized flow indication.

The pressure rating of the flow meter and flanges shall be equal to or greater than that of the pipeline within which it is installed. The preferred location for the flow meter converter/transmitter units is within a building. Where this is not possible, then the converter shall be installed in a suitable above ground enclosure providing the converter with suitable mechanical and environmental protection.

The flow signal converters/transmitters shall provide 4-20mA output linearly proportional to the rate of flow and shall provide a pulse output for flow totalizing. The flow meter electronic supervisory unit shall display the following on a minimum:

- Flow rate;
- Flow total/totalizer;
- High flow rate alarm;
- Low flow rate alarm.

Signals for the items above shall form inputs to the PLC and SCADA and be utilized within Operator displays. The integrator used for the second item above shall have at least six digits.

Each flow meter shall be provided with downstream and upstream isolation valve including the washout facility.

Note: - As per process requirement Inline Multi-Path Ultrasonic Flow Meters shall be installed for the online measurement of Air Flow and Gas Flow rates and the same shall be shall be provided by the STP contractor at particular Subsystem packages of the entire STP.

A. Electromagnetic Flow Meter

Full bore electromagnetic flow meters shall be designed, manufactured and calibrated to ISO standard. The flow meter shall be capable of measuring bi-directional flow.

Technical Specification

(i) Process Liquid

a.	Liquid Type	Domestic/other wastewater and other STP process streams, including sludge of varying solids concentration

(ii) Operating Condition

a.	Operating pressure	As per flange rating (Process Requirement)
b.	Operating temperature	As per Process Requirement.

(iii) Flow Sensor

a	Type	Pulsed DC excitation
b	System	Separate with cable output
c	End connections	Flanges of Carbon Steel
d	Electrode material	SS 316 (Stainless steel) / Platinum / Tantalum
e	Meter tube	As per Process Requirement.
f	Electrode type	As per Process Requirement
g	Lining material	As per Process Requirement.
h	Protection category	IP 68
i	Measuring accuracy	Measuring accuracy + / - 0.5% of measured value inclusive of linearity, repeatability, pressure effect and hysterics between 0.5 – 5 m/s velocity
j	Connection / Junction Box	SS 304
k	Earthing	Grounding Rings in SS 304
l	Fluid conductivity	> 20 Siemens / cm (Or Minimum as per Manufacturer's recommendation)
m	Marking	Direction of flow with arrow, size, Sr. No., make

(iv) Flow Transmitter / Converter

a	Type	Miscoprocessor based, Modular Design, remote mounting
b	Display language	English
c	Ambient temperature	-2°C to +60°C
d	Display	4 digit backlit LCD / LCD , for flow rate in m3/hr. 8 digit backlit LCD / LCD for totalized flow in MLD.
e	Outputs	One scaleable pulse output One status output One Integrator Output
f	Protection Category	IP 67
g	Enclosure	Die Cast Aluminum with polyurethane finish with glass window
h	Programming	optical touch key / Updated Running version
i	Power Supply	230 V AC, 50 Hz (or As per Site condition)
j	Cable Gland	1/2" NPTF- National Pipe Thread(female) (4 glands of double compression type)
k	Mounting	Wall mounted / Panel mounted
l	Interface	RS 485, based on EIA R 422/485 standard, or HART
m	Power failure mode	Provision of RAM / EEPROM to store parameter entered and measured flow data during power failure
o	Max. Separation	Upto 200 mtrs between sensor and transmitters within prefabricated cable.
p	Interchangeability	Fully interchangeable with all sizes of flow sensors
q	Safety classification	General purpose certification
r	Backup power	From Plant UPS
s	Password protection	Required
t	Cable	Required
u	Lightning protection	Required

Note: - Non Contact type Measurement with Clamp on Ultrasonic Type Flow meters shall be Provided, Where Full Bore Electromagnetic Flow meter is not possible to install at Distribution chamber areas/Incoming sewer lines.

(v) Digital Flow Indicator cum Flow Integrator

Digital flow indicator cum flow integrators shall be modular in design. It shall consist of two separate dedicated displays for flow rate indication and total flow indication. It shall accept 4-20 mA DC isolated input. The flow integration shall be carried out in the Programmable Logic Controller (PLC). The flow indicator cum flow integrator shall provide 4-20 mA retransmission output proportional to flowrate. It shall have RS 485 communication port for connectivity to PLC.

Technical Particulars

Type	Electronic (Combined unit)
Mounting	Front facia of Instrument Control Panel(ICP)
Display	Back-lit LCD or LED
Digit height	12.5 mm or higher
No. of digits for	
i. Flow rate indicator	As per Process Requirement.
ii. Flow integrator	As per Process Requirement.
Input	4-20 mA DC (isolated)
Zero and span adjustment	Required
Manual reset facility for flow integrator	Password protected
Engineering Units for Flow rate indicator	As per Engineers Approval
Flow integrator	As per Engineers Approval
Power supply to transmitter	Required (As per Engineers Approval)
Battery backup for integrator	Required (As per Engineers Approval)
Retransmission output	4-20 mA proportional to flowrate
Alarm outputs	2NO+2NC for high and low alarms
Communication port	RS-485 (With Modbus protocol) for interfacing with PLC.
Weather protection class	IP-52 of IS 13947
Accuracy	± 0.25% of span or better

B. **Inline Ultrasonic Flow Meters:-** These flow meters are required for Measurement of Air Flow rates at Process Air blower Discharge Lines to Individual Aeration Basins and also to measure the gas flow rates on common discharge line for Biogas Mixing Blowers, Biogas inlet flow to Biogas Scrubber Package system, Biogas Blower Discharge flow to Hot Water Boilers and Biogas Flare System.

To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow meter shall be provided, as recommended by the flow meter manufacturer. Contractor shall finalize the exact location of Installation of proposed flow transducers in consultation with Engineer's Representative.

The flow converter / transmitter shall be mounted directly on the measuring tube (Compact type)

It shall process the input signal from measuring sensor and provide 4-20 mA DC output proportional to flow rate.

Flow transmitters shall have LCD display to indicate the process flow rates. The flow range, other flow parameters settings shall be adjustable based on password protection except calibration settings.

Flow measurement shall not be affected by physical properties of temperature, pressure, density, etc., within given limits. The contractor shall provide compensating electronic circuit with Flow Converter / Transmitter (or) those shall be provided with programmable feature in the PLC for getting accurate Flow readings.

A Cabinet shall be provided for Flow converter / transmitter and associated accessories if required, it shall be fabricated from cold rolled steel with powder coating sheet of minimum 2mm thick and shall be suitable with side clamps mounting as required. The cabinet shall be properly painted from inside by white paint and from outside by paint shade RAL 7032.The cabinet shall conform to IP-65 protection and shall have built in locking facility. the cabinet shall be earthed properly. A steel plate / pipe, as per the requirement, shall be provided in the cabinet for mounting the instrument and accessories.

Technical Specification for Inline Ultrasonic Flow meters:

a) General

Applications	:	1) Online Measurement of air flow rates at Process Air Blowers Discharge lines to individual Aeration Basins. 2) Online measurement of gas flow rates along with Methane (as compensated parameter) on each common discharge line for Biogas Mixing Blowers. 3) Online measurement of gas flow rates at Biogas inlet flow to Biogas Scrubber Package system, Biogas Blower Discharge flow to Hot Water Boilers and Biogas Flare System.
Line sizes	:	As per process requirements
Range setting	:	As per process requirements and adjustable over full span and selectable with password protection.

b) Flow Sensor / Flow tube

Type	:	Inline Ultrasonic Type Flow Meter to be assembled in a factory
Number of Paths	:	2-Path measurement (Clamp on type or Insertion types are not acceptable)
Measuring principle	:	Transit time Principle
Measuring accuracy	:	Measuring accuracy shall be less than + / - 1% of measured value inclusive of linearity, repeatability, pressure effect and hysterics between 0.5 – 5 m/s velocity
Weather Protection Class	:	IP 67
Electrode material	:	Titanium
Measuring Flow Tube	:	SS316L
End connections	:	Flanges of SS
Rating of the Flanges	:	As per process requirement
M.O.C for factory mounted Transducer holders, Transducer cabling tube & Transducer mounting plates	:	SS316L
Transducer O-rings	:	Required (Factory Mounted)

c) Flow Converter / Transmitter

Output	:	4-20 mA. DC (isolated)
Zero and Span Adjustment	:	Required (protected with password)

Weather protection class	: IP- 67
Housing Material	: die-cast aluminium, polyurethane coated
Display	: LC display, backlit white, Measured Air/Gas Flow rates etc..
Keys	: 4-optical keys for operator control
Earthing	: Grounding accessories shall be provided
Power supply	: 24 V DC

C. Calibration for Flow meters

The flow meters shall be calibrated for the accuracy of velocity measurement wherein the velocities shall correspond to the flow range of the flow meter covered in the tender. The calibration shall be carried out for all flow meters (100%) under test, consisting of flow sensors and flow transmitter cum computation unit.

The calibration method shall be either gravimetric method or volumetric method. The "test bed's shall be accredited by national /international certifying authority as per ISO 8316 (Calibration by Volumetric Method) or ISO 4185 (Measurement of fluid flow in closed conduits – weighing method).

The Contractor shall produce accreditation certificates for the test facility and the calibration certificate for the flow meter for review by Engineer and shall also demonstrate complete calibration on the test bed in the flow meter laboratory during witnessing of the Factory Acceptance Test. The flow meter shall be acceptable if the accuracy and repeatability is equal to or better than those specified.

Site calibration- Site calibration will be arranged and shown to prove the accuracy of actual Flow.

13.5 Sewage pumping station (SPS) Control

The sewage pumping station (SPS) shall be controlled through Fully Auto-Mode by STP Redundant Control System with Duty Rotation Logic Implemented by the PLC Programmer based on Approved Control Philosophy Write-Up. In any case Failure of STP Redundant Control System, the entire SPS operation shall also be controlled through Manual-Mode from Electrical Control Panels or Local Push Button Stations along with their Emergency-Stop Push Buttons.

Note: - In any Mode of Operation, all Emergency-Stop Push Buttons are always in Active Mode and send their Feedbacks to STP Redundant Control System.

The minimum SPS processes / or any other systems in entire STP following I/O's that shall be controlled and monitored by the STP Redundant Control System are as below:

Pump, Motor: Start, Stop, Auto /Manual, Run, Emergency Stop, Fault
Valve: Auto/Manual, Open, Close, Travelling Indication, Fault
Drives/VFD: Start, Stop, Auto /Manual, Run, Available, Emergency Stop, Fault, speed, voltage/current
Level Indicator: HH, H, L, LL, Analog value, Alarm
Level Switch: HH, H, L, LL, Alarm
Hand Switch: L, O, R
Pressure Indicator/transmitters (in addition to individual pumps, at common discharge end of pumps): Analog Value, Alarm
Flow Indicator/Transmitters (at common discharge end of pumps, Analog value, totalizer, Alarm
Emergency Stop: pumps, valves. Drives, motor, etc...

Note:-

i) **Breaker Control requirements** shall be followed as per Part-6 of General Electrical specifications, For this contractor has to submit with a separate I/O schedule to Electrical Discipline for review/approval.
ii) Bidder has to provide all the necessary interlocks & Protections (as per Electrical & Process parameters) as per the Operational Requirements.

13.6 Chlorination Instrumentation and Control

Fully automatic chlorine injection system shall be provided for STP

The chlorination systems shall be supplied with a chlorination control units. The chlorination control units shall be integrated by means of serial link with the station SCADA for remote monitoring and control of the chlorination system. The serial communication system shall be based on internationally implemented standards. The design of communication system chosen shall ensure that there is sufficient capacity and facilities (including future spare of 30%) to enable the system to achieve the time-stamping and response performance.

The facilities to monitor and operate the chlorine system shall be provided at the local control panel within the chlorination room. All alarm and status indication shall be indicated on the station SCADA and Master Control Center at BDA main office Kumara park west or Central Administrative Building at Sector 1, Bengaluru via the redundant wireless GPRS communication system.

The residual chlorine analyzer shall continually measure the concentration of free chlorine residual present and, by control of the chlorine dosage rate, shall maintain the predetermined concentration. The residual analyzer shall have the capability to initiate high and low alarm locally and to SCADA.

13.7 Blower system Instrumentation & Control

The blower system shall be supplied at STP with a local control unit. The local control unit shall be integrated by means of redundant serial link with the STP SCADA for remote monitoring and control of the blower control system. The serial communication system shall be based on internationally Implemented standards. The design of communication system chosen shall ensure that there is sufficient capacity and facilities to enable the system to achieve time-stamping and response performance.

All alarm and status indication shall be indicated on the STP SCADA.

The STP contractor shall include all associated instrumentation required for control and monitoring of process (locally & remotely) under his scope of work. The details shown in P&ID are indicative only and shall be provided on a minimum.

The typical I/O or instrumentation to be provided shall include on a minimum pressure transmitters on the individual outlet of blowers along with pressure gauges, pressure transmitter and air flow meter on the common discharge outlet. Blower control shall be based on DO feedback, flow and pressure interlocks on a minimum.

The STP contractor shall ensure that data from the blower control system can be read and displayed at the Station SCADA. Ethernet communication shall be used to communicate with the local automation system. The above feature should be demonstrated during FAT& SAT.

13.8 Feed/Dosing pumps control

All dosing pumps shall provide a pulse output and accept pulse input. The dosing rates of all pumps shall be monitored and controlled by the main STP PLC based SCADA system. All feed and dosing pump shall be controlled in auto mode. Facility shall be provided for control of the pumps in manual mode in the event of auto mode failure. The contractor shall take note on the requirement.

13.9 Level Measuring System

(i) Conductivity type level switches

Conductivity type level switches shall be provided in pump pits, TSPS Wet wells , drain pit for complete auto control of pumps . The weather protection class for sensor and controller shall be IP-65 of IS 13947. Each level detector shall be of conductivity type and comprise of PVC insulated rigid stainless steel electrodes.

(a) Technical Particulars for Electrodes / Probes

(i)	No. of electrodes	:	As per Tender P&ID(Eg:- for Pump Pits, drain pits and Plant water Tanks, Coarse screens(Inlet),TSPS Wet well etc... where ever applicable as per Tender P&ID)
(ii)	Material of Electrodes	:	SS 316, Rigid with PVC/PTFE coating.
(iii)	Mounting	:	Flanged; 150 LBS ANSI B.16.5
(iv)	Length of electrodes	:	To be finalised during detailed engineering as per process requirement.
(v)	Spacers between electrodes	:	Required
(vi)	Stilling pipe	:	Required (SS 316)
(vii)	Weather protection class for level probe	:	IP 65 of IS 13947

(b)	**Level Controller Type**	**:**	**Field Mounted**
(i)	Switch Contact (for each setting)	:	2 NO + 2NC
(ii)	Contact rating	:	240 V AC, 2A
(iii)	Sensitivity control	:	Required
(iv)	Weather protection class	:	IP-65 of IS 13947
(v)	Cabinet for mounting level Controller	:	Required

Note: - Magnetic Type Float Level Switches shall be provided instead of Conductivity type switches for the following Sub systems of STP such as Chemical Storage Tanks, Alum Preparation Tanks and

Polymer Tank Mixers ect.. (Where medium of the fluid shall be chemical solution there Magnetic type float Switches are applicable)

(ii) Ultrasonic Level Meters

Technical Particulars

(a) General

(i)	Service	:	Level Measurement at different sub systems of entire STP process (As Per Process Requirement)
(ii)	Quantity	:	As per Process Requirement.
(iii)	Range	:	As per process requirement.
(iv)	Accuracy	:	± 0.5% of full scale of measuring Loop

(b) Sensor and transmitter

(iv)	Output	:	4 - 20 mA
(v)	Mounting	:	Top Mounted, Flanged 150 lbs, B16.5, SS
(vi)	Programming	:	Required facility with programmer
(vii)	Weather	:	IP – 65 of IS – 13947 Protection class
(viii)	Stilling pipe	:	Required
(ix)	Power Supply	:	24 VDC or as per site condition

(c) Digital display unit

(i)	Type	:	Electronic micro processor based
(ii)	Display	:	Digital, 3 $^{1}/_{2}$ digit LCD
(iii)	Engineering	:	Meters or As per Process Requirement Units
(iv)	Accuracy	:	± 0.1% of full scale.
(v)	Input	:	4-20mA from sensor/transmitter.
(vi)	Alarm	:	2NO+2NC, (adjustable). Contact
(vii)	Contact	:	240V AC, 2A Rating
(viii)	Retransmission	:	Required. Analog output
(ix)	Weather	:	IP – 52 of IS – 13947 Protection class

13.10 Pressure Gauges & Transmitters and Pressure Switches

Pressure gauges shall comply with BS EN 837-1 or equivalent Indian standard and have concentric scales. For specially arduous duty where the gauge is subject to pressure pulsations and/or vibration, it shall be provided with a glycerine-filled dial and line snubbers shall be used.

Bourdon-tube type differential-pressure gauges shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage to or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved Corrosion-resistant material. Where necessary, a Schaffer diaphragm type of pressure gauge shall be used to segregate the gauge tube from a corrosive fluid media. In chlorine and sulphur dioxide applications, the diaphragm shall be in silver or tantalum. For other fluids an appropriate diaphragm material shall be used.

The minimum diameter for round pressure gauges shall be 100mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

Unless specified elsewhere the accuracy for pressure gauges shall be 1% of range, for diaphragm gauges 1% of range and for differential gauges 1.5% of range or better.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation shall be marked on the dial.

The zero and span of a pressure transmitter shall not change by more than 0.1% of the span per Celsius degree change in ambient temperature.

Pressure transmitters shall have an accuracy typically better than 0.1% of span, depending on the application and shall be protected to BS EN 60529: IP 65 standard or higher standard (or equivalent Indian standard). For transmitters installed in meter chambers liable to flooding or underwater applications, they shall be to BS EN 60529: IP 68 standard (or equivalent Indian standard) and shall operate up to maximum submergence of 20 metres of water.

Pressure transmitters shall provide a digital or 4mA to 20mA dc output proportional to the pressure range.

Pressure gauges and transmitters shall have primary isolating valves, 2 or 3 way valve manifold and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.

Technical Specifications for Pressure Switches

Electro-mechanical pressure switch shall be provided to operate in the range of operator desired pressure set-point as per process requirement wherever applicable for Gas pressure lines in entire STP package. The pressure switch shall have a manually adjustable set point and differential switching level for Hardwired interlock protection to specific actuators.

The Pressure switch shall be suitable for Insertion type over Gas pipelines. The switch shall be provided complete with an isolation valve and surge damper device.

(i)	Type	:	Non-Indicating
(ii)	Quantity	:	As per process requirement
(iii)	Sensing Element	:	Bourden tube / Bellows
(iv)	Switch type	:	Micro switch
(v)	Set pressure	:	Adjustable
(vi)	Accuracy	:	± 1% of span
(vii)	Switch Contacts	:	2 NO. + 2 NC.
(viii)	Switch Rating	:	240 V AC, 2A
(ix)	Impulse, Tube, Fitting, Isolation valve, Snubber and other installation hardware	:	Required
(x)	Switch Differential	:	Adjustable
(xi)	Weather Protection class	:	IP – 65 of IS – 13947

13.11 Strain-gauge Pressure Transducers, Load Cell Weight Indicator and Transmitters

13.11.1 Strain-gauge Pressure Transducers and Transmitters

Strain-gauge pressure transducers shall use thin film sensors without bonding. Each instrument housing shall be of all-welded Grade X 4 CrNiMo stainless steel or equivalent and hermetically sealed. Non-interacting, zero and span adjustments shall be provided on each transducer. The measuring diaphragm shall be isolated from the process fluid by a non-corrodible barrier diaphragm.

The mean time between failures for any model of strain-gauge transducer shall be not less than 15 years, and the performance of the measurement system shall be as given below or higher performance:

- Accuracy: ±0.1% of calibrated span, including linearity Hysteresis and repeatability;
- Repeatability: ±0.05% at maximum span;
- Stability: ±0.1% of upper range limit over 6−month Period;
- Over-pressure: sustain a 400% over-pressure without damage;
- RFI / EMI effect: less than 1% of span with 500MHz at 5W direct contact;
- Power-supply variation effect: 0.01% per volt variation.
- Load variation effect: ±0.0002% per ohm of loop-resistance variation.
- Temperature: −29°C to +82°C range; total thermal error of ±0.75% of span over 0°C to 50°C;
- Protection: IP 65.

Strain-gauge transducers which do not have terminals for their cable connection, shall have integral sealed-cable assemblies, installed in conduit and terminated at weatherproof junction boxes, protected to IP 65 each mounted near to its associated process transmitter. A digital or 4mA to 20mA dc output signal proportional to the transducer range shall be provided.

Strain-gauge pressure transmitters shall be generally as the transducer except that it shall incorporate a waterproof pressure transmitter producing a digital or 4mA to 20mA output signal.

Provision for transducer venting shall be provided.

13.11.2 Strain-gauge Load Cell Weight Indicator and Transmitters

Weight Indicator Transmitter Comprising of Compression Type Strain Gauge Load Cells along with Transmitter and Indicator for measurement of Sludge Hopper Weight Applications in Sewage Treatment Plant.

The Operating Principle of the Strain Gauge is "The resistance of an Electrical conductor changes with a ratio of Applied Stress and Changes in its Length of the Material" Copper Nickel Alloy is commonly used in Strain Gauge Construction because the resistance change of Foil is virtual proportional to the applied Strain.

Strain Gauges are mounted on the top and bottom to measure Tension and compression forces. Because the strain Gauges are vulnerable to damage, they are typically covered by Bellows. The Beam itself often is made of rugged alloy steel and protected by Nickel Plating.

The Strain Gauge Amplifier is a purpose designed Hybrid, Low noise, Low Drift specifically configured for resistive Bridge Measurement. When Strain Gauges are used in compressive Load Transducer applications a full bridge circuit is used with active Gauges in all four arms of the Bridge.

Technical Particulars

Measuring Range	:	As per Process Requirement
Temperature Range	:	-30^{o}c to + 80^{o}c
Gauge Length	:	8mm
Gauge Width	:	2mm
Gauge Factor	:	2.1
Base Length	:	13.0mm
Base Width	:	4.0mm
Base diameter	:	21.0mm
Accuracy	:	+/- 0.5 % of Measured Value
Supply Voltage	:	24 V DC
Output	:	4-20mA
Indicator Display	:	Required

13.12 Temperature-Measuring System

13.13.1 Temperature Meters

Unless otherwise specified, platinum resistance elements shall be used for measuring spans of up to 200°C and chromel-alumel thermocouples for spans exceeding 200°C.

The accuracy for temperature meters shall be ±0.03% of span. Configuration data shall be stored in the EEPROM memory.

In critical and important application, the temperature sensors shall be of a dual type arrangement for easy replacement. Each temperature sensor, unless otherwise specified, shall have a stainless steel thermo well, or pocket-and-extension assembly, non-corrodible metal sheath and waterproof terminal head. Pockets for steam, oil and pressurized-water lines shall be welded; pockets for other duties shall be screwed. The sensor assembly shall be designed to permit removal of the temperature element without twisting the leads.

Platinum resistance thermometers shall comply with BS 1041 and BS EN 60751 or equivalent Indian Standards on the approval of the Engineer. Sensors shall have a resistance of 100 ohms at 0°C and shall conform to the European standard curve (DIN 43720), where Alpha = 0.00385. Each element shall be artificially aged during manufacture. Terminal heads and amplifiers shall be designed for four-wire connections between head and amplifier. Platinum resistance elements shall be spring-loaded and fully encapsulated in ceramic material and the elements and high-temperature-resistant lead wires shall be hermetically sealed. The associated resistance-to-current converters shall have zero and span adjustments and input-output circuit isolation.

Thermocouples shall be of the mineral-insulated type and unless otherwise specified shall be of the chromel - alumel (nickel-chromium v nickel-aluminum) type and shall comply with BS 1041 and BS EN 60584-1.

Thermocouple junctions shall be welded. Ceramic-insulation material may be used for base-metal thermocouples but low-silicon insulation material shall be used for noble-metal thermocouples. Thermocouple systems shall have thermoelectric ice point reference chambers or receivers or amplifiers with automatic cold junction compensation.

Thermocouple receivers and amplifiers shall also have zero and span adjustment, common and series mode interference rejection circuits, radio-frequency filters, input-output circuit isolation and thermocouple break feature whereby the output is driven to zero or full-scale, as stipulated by the Engineer, when the receiver or amplifier input circuit is broken.

Thermocouple elements shall be electrically isolated from their sheaths but each terminal head shall have facilities for earthing the thermocouple and for terminating the screen of the extension or compensation cable.

Amplifier chassis shall have facilities both for being earthed to the instrument case via a capacitor and for being electrically isolated from the instrument case.

Temperature transmitters shall be of rugged construction microprocessor based instruments. They shall provide simultaneous digital and analogue outputs and the 4mA to 20mA dc output shall be linear with temperature.

13.13.2 Temperature Switches

Temperature switches shall have contacts with differing "cut-in" and "cut-out" values. Their nominal operating points shall be fully adjustable over the whole range of the instrument and the set-value shall be clearly indicated by a dial and pointer.

Note:- RTD"s of Winding and Bearing Temperatures of Pumps / Motors shall be monitored through Temperature Scanner Indicators as per Clause No:7.12.6 of Temperature Monitoring System.

13.13 On-Line Analytical Instrumentation &Measurement

13.14.1 DO Measurement/Analyzer

Aeration Tank DO

General

The sensor should be unaffected by pH swings, hydrogen sulfide, wastewater chemicals, heavy metals, or organic build-up on the sensor. Warm-up time is not required so the analyzer can start measuring within 30 seconds of switching on.

The dissolved oxygen probe shall be a continuous-reading probe that utilizes luminescent sensor technology.

The probe material shall be foamed Noryl® and 316stainless steel. All parts of the probe shall be corrosion resistant and fully immersible.

The sensor material shall be polybutyl methoacrolate.

The operation of the analyzer shall not be affected by H2S,pH, K+1, Na+1, Mg+2, Ca+2, NH4 +1, Al+3, Pb+2, Cd+2, Zn+2, Cr (total), Fe+2, Fe+3, Mn+2, Cu+2, Ni+2, Co+2, CN- 1, NO3-1, SO4 -2, S-2, PO4+3, Cl-1, anion active tensides, crude oils, or Cl2 -1. -1.

The probe shall provide electrolyte-free operation without the requirements of sample conditioning.

The probe shall be furnished with choice of pole or ball float mount kit.

The sensor cap shall be warranted for one full year against defects in material and workmanship.

The probe shall be warranted for three full years against defects in material and workmanship.

The analyzer sensor shall be Luminescence dissolved Oxygen (LDO) type.

Minimum of One Luminescence dissolved oxygen (LDO) Sensors along with Transmitters and 2 probe holders in each anoxic compartment of Bioreactor/Basin and Minimum of two (2) Luminescence dissolved oxygen (LDO) Sensors along with Transmitters and with minimum of Four (4) probe holders in each aerobic compartment of Bioreactor/Basin shall be provided.

The Probe / Sensor should be of detachable type and should be supplied along with Transmitter / Converter.

Service	Measurement of Dissolved Oxygen in the Aeration Tank.
Repeatability	± 0.5% of span
Range	0 – 20 mg/L(ppm)
Accuracy	Below 1 ppm: ±0.1 ppm , Above 1 ppm ±0.2 ppm
Response time at 20oC	To 90% in less than 40 seconds , To 95% in less than 60 seconds
Operating Temperature	0 to 50°C (32 to 122°F)
Sensor	
Type	Immersion Type
Mounting	In Aerobic Tank
Installation hardware and	
Integral	Required
Cable	
Probe Material	Suitable for Sewage application
Sensor Cable (Integral	10 m (33 ft.) terminated with quick-disconnect plug
Wetted Materials	Probe : Foamed Noryl ® and 316 stainless steel
Sensor	Polybutyl methacrolate
Transmitter	
Type	Microprocessor Based having back Lit LCD display
Mounting	Field
Prefabricated integral cable for	
Connecting sensor and	
transmitter	Required
Analog outputs	4 –20 mA

13.14.2 ORP Measurement/Analyzer

General:

Design to be differential electrode measurement technique with easily replaceable salt bridge / protector Built in encapsulated preamp, protects the sensor's built-in preamp from moisture and humidity, ensuring reliable sensor operation.

Durable body materials suitable for chemical compatibility with most process solutions
With Versatile mounting solutions
Should have differential sensor warranty
Should be compatible with digital controller
Sensor should have hex shaped body to facilitate mounting
Should have the built in integral temperature sensor

> One ORP meter in each anaerobic compartment of Bioreactor/basin shall be provided.

> Chlorine Contact Tank ORP.

General	
Service	Measurement of Oxidation Reduction Potential in the Chlorine Contact Tank.
Repeatability	± 20 mV
Range	-2000 – 2000 mV/-1500 to + 1500 mV
Sensor	
Type	Immersion Type
Mounting	In Chlorine Contact Tank
Installation hardware and Integral cable	Required
Probe material	Suitable for Sewage application
Operating temperature range	Analog Sensor: - 5 to 105 deg C
Digital Sensor	- 5 to 70 deg C
Pressure range	0 to 6.9 bar
Type of Ground Electrode	titanium ground electrode to eliminate ground Loop currents in the measuring electrodes.
Sensitivity	=/- 0.5 mV
Stability	2 mVper 24 Hours, non cumulative
Flow rate	3 m (10feet) per second maximum
Built in temperature element	NTC 300 ohm thermistor for analyzer temperature Readout
Sensor Cable	4 conductor cable with one shield and polyurethane and polyurethane jacket rated to 105 deg C
Transmitter	
Type	Microprocessor Based having back Lit LCD display
Mounting	Field
Prefabricated integral cable for connecting sensor and transmitter	Required
Analog outputs	4–20 mA

13.14.3 Residual Chlorine Measurement/Analyzer

(i) General	
Service	Measurement of residual chlorine
Cycle time	One complete sample analysis every 2-1/2 minutes
Range	0 to 5mg/L free or total residual Chlorine, with automatic color/turbidity compensation
Accuracy	±5% or 0.035 mg/L as Cl2, whichever is greater
Precision	±5% or 0.005 mg/L as Cl2, whichever is greater
Minimum Detection Limit	0.035 mg/L
(ii) Sensor	
Type	Colorimetric Type
Mounting	Off line
Installation hardware and Integral cable	Required
Probe material	Suitable for Sewage application
Transmitter	
Type	Microprocessor Based having back Lit LCD display
Mounting	Field
Prefabricated integral cable for	

connecting sensor and transmitter	Required
Power	100-115/230 Vac, 50/60 Hz (switch selectable), 90 VA
Enclosure	maximum\ ABS plastic, IP65 enclosure rating with two clear polycarbonate windows
Analog outputs	One 4-20 mA with an output span programmable over the 0 to 5 mg/L range.

Note: Online Analytical Instruments for Water quality monitoring for feed water to boiler shall be provided, Bidder has to supply, any other On-Line Analytical Instruments as per P&ID or Process requirements.

13.14 Deleted
13.15 Deleted

13.16 Approved Vendor/Manufacturer/Make List – Instrumentation

(i) List of Makes for Instruments:

S. NO	DESCRIPTION	VENDOR/MANUFACTURER/MAKE
1	Level Indicator Transmitter	M/s EMERSON M/s ABB, M/s Nivelco M/s Royce Instruments M/s Global Water M/s Endress+Hauser M/s Pulsar M/s Kobold M/s Yokogawa M/s Siemens
2	Flow meters/Flow Indicator/ Transmitter	M/s EMERSON M/s ABB M/s Royce Instruments M/s Dynameters M/s Pulsar M/s Yokogawa M/s Endress+Hauser M/s Krohne Marshall M/s Siemens
3	Level/Float Switches	M/s EMERSON M/s ABB M/s Nivelco M/s Royce Instruments M/s Endress+Hauser, M/s Kobold M/s Pune Techtrol
4	Pressure Gauges/Pressure Switches	M/S Warry M/S ABB, M/s Wika M/s Kobold M/s Gen Inst Co M/s Switzer M/s Dandfoss
5	Pressure Indicator Transmitter	M/s EMERSON M/s ABB, M/s Kobold M/s Switzer M/s Rosemount M/s Endress+Hauser

S. NO	DESCRIPTION	VENDOR/MANUFACTURER/MAKE
		M/s Siemens
6	Online Residual Chlorine Analyzer	M/s Hach Company M/s SWAN M/s HF SCIENTIFIC, INC M/s Endress+Hauser M/s Yokogawa
7	Temperature Indicator Transmitters	M/s Kobold M/s Endress+Hauser M/s ABB M/s Hach Company
8	Analytical Online Instruments (DO, ORP,, etc.)	M/s Hach Company M/s Jenco M/s Endress+Hauser M/s ABB M/s SWAN M/s HF SCIENTIFIC, INC M/s WTW M/s Toshcon M/s Yokogawa
9	Online Influent & Effluent Analyser	

(ii) List of Makes For UPS & Batteries:

(a) List of Makes for UPS

S. NO	MANUFACTURER / MAKE
1	M/s APC
2	M/s DB & ELECTRONICS
3	M/s HI-REL
4	M/s NUMERIC POWER SYSTEMS

(b) List of Makes for Batteries

S. NO	MANUFACTURER / MAKE
1	M/s AMAR RAJA
2	M/s HBL NIFE
3	M/s AMCO
4	M/s EXIDE

iii) List of Makes for Cables

S. NO	MANUFACTURER / MAKE
1	M/s Universal Cables
2	M/s Polycab
3	M/s Havell‟s
4	M/s CCI

S. NO	MANUFACTURER / MAKE
5	M/s Finolex
6	M/s NICCO
7	M/s Delton Cables Limited
8	M/s Thermo cables

(iv) List of Makes for Enclosures/ Panels

S. NO	MANUFACTURER / MAKE
1	M/s Rittal
2	M/s ECIL

(v) List of Makes for Alarm Annunciators

S. NO	MANUFACTURER / MAKE
1	M/s ALAN
2	M/s Unitech Instruments
3	M/s Minilec

(vi) List of Makes for Process Indicators

S. NO	MANUFACTURER / MAKE
1	M/s Masibus
2	M/s Unitech Instruments

In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following:

1. Provide evidence from the manufacture of the proposed equipment and demonstrate that the makes are superior/Equivalent to the approved makes.
2. Manufacturer involved in manufacture of specified equipment for at least 10 years before bid date.
3. At least 3 successful installations commissioned in last 5 years before bid date and satisfactorily operating for at least one year before bid date
4. Manufacturer to provide full contact information for each reference as part of technical bid.

And the above qualities and requirements shall be demonstrated and evidenced by inspection of manufacturing units and successfully installed plants (End users) for the equipment's desired and successful operation and certification by the Employer/Engineer (BDA)/Representative.

13.17 Process Plant Operation Philosophy

(a) General

The control system in addition to providing the facilities detailed in the preceding clauses shall provide the following process plant specific requirements.

In case of power failure, all equipment that was in operation immediately preceding the power failure, except for equipment not wired to run on standby power, shall automatically restart when the standby generator starts. When main power is restored, all equipment that was in operation immediately preceding the power failure, including equipment not wired to run on standby power, shall automatically restart. All restart sequences shall be implemented with delay timers set to prevent the simultaneous start up of all equipment. The restart sequence shall follow a general downstream-to-upstream direction with respect to treatment process flow, i.e., start downstream equipment first and then move upstream in steps.

13.18 Control Philosophy

13.19.1 General Control Philosophy

This section describes the general control philosophy that the Contractor shall follow for STP included in this contract. These requirements are specified for tender purposes only and the information provided is not intended for construction. The bidders/contractors shall submit more detailed and specific versions of the control philosophy and the functional design specifications in both the bidding and design stages.

The contractor shall note that the STP shall be designed to operate in fully automatic (auto mode) of operation at all given times. In the event of failure of the same, facility shall be provided to operate the plant in manual mode till such time the auto mode is again available. Design shall incorporate level, flow and pressure interlocks to ensure plant is operated in a safe condition at all times and to ensure maximum uptime. Contractor shall note the importance of this requirement.

The STP included in this contract shall comprise items, components, and unit processes described in Process Requirements and elsewhere in these bid documents, and shall include but not be limited to all supporting and ancillary equipment, accessories, instrumentation, controls, automation, and any and all other components required for proper, easy, and automated operation and functioning and for accomplishing the specified performance objectives.

Incoming raw sewage will be collected at receiving chamber, screened by mechanical coarse screens located upstream of raw sewage pump station, screened flows diverted to raw sewage pump station. Further by pumping, the raw sewage is allowed to pass through fine screens. By gravity the flows are routed through Grit remover for further screening and degritting of the sewage at grit removal system.

The de-gritted sewage shall flow by gravity to the aeration basins for biological treatment. Mixed liquor recycle (MLR) pumps installed in the aeration basin effluent channel shall recycle mixed liquor to the anaerobic and/or anoxic zones of the aeration basins to accomplish denitrification. The treated effluent from SBR tank shall flow by gravity to the chlorine contact tanks. Sludge collected from SBR tank routed to sludge sump and pump station. Effluent from SBR tank shall be disinfected in the chlorine contact tanks and through disc cloth filter before being discharged by gravity to the receiving waters via an outfall pipe.

The collected sludge shall be passed through sludge thickener and then to Centrifuge for reduction of the sludge volume. A polymer system shall be provided for conditioning of the sludge before dewatering. Dewatered sludge shall be conveyed to a sludge dryer unit.

The STP control system shall include a dual hot standby central main plant PLC. Typically, signals from individual or isolated field instruments within a physical distance of approximately 150 meters from the main plant PLC shall be transmitted directly to the main plant PLC. Signals from instrument groups belonging to common unit processes, control loops, or package systems, or signals originating more than 150 meters away from the main plant PLC, shall typically be transmitted to RIO (Remote Input/output) panels or local control panels dedicated to the respective unit processes, control loops, or package systems. The following specific systems shall be provided with their own dedicated PLC, and all signals from these systems shall be transmitted to their respective PLCs.

- Screens, pump stations & Primary Treatment
- Secondary treatment & Disinfection system
- Process Air Blowers
- Chlorinators
- Sludge handling system

The control logic for the above systems shall be programmed by the system supplier into the system PLC. However, all signals received or generated by the system PLC, including alarms, shall also be transmitted to the STP SCADA HMI for monitoring, and operator shall have option to provide all required operator input (including but not limited to set points, start/stop control, open/close control, speed control, etc.) either at the system PLC or at the STP SCADA HMI.

All signals shall be transmitted using redundant FOC (Fibre Optic Cable). A central control room shall be provided in the administration building at the STP. The following shall be provided in the central control room at a minimum:

- Dual redundant SCADA system
- Historian system
- Network printers and managed Ethernet switches

The Contractor shall develop a logical, meaningful, modular, and expandable tag numbering system for all control elements, including but not limited to equipment, instruments, actuators, and control loops. The numbering system shall be such that components of the tag number provide immediate indication of the type of element (e.g. pump, blower, gate, valve, mixer, flow meter, etc.), its location and/or unit process, and the number of similar modular units proposed. The system shall allow for easy modifications such as future addition of units for expansion. The Contractor shall submit the tag numbering system for Engineer's review and approval prior to implementation.

The Contractor shall submit for Engineer's review and approval I/O lists in each hierarchy level such as field level, local control panel, local electrical/MCC room level, STP central control room level, and the Sewage Master Control Centre. The I/O list shall be categorized into discrete input/output signals, analog input/output signals, signals through field bus, and signals through LAN communication at each level. The list shall also contain process/equipment status and alarm/fault signals, commands to process, and log items for historical records. All alarms shall be visually and prominently indicated at the local panel, the STP SCADA HMI, as well as the Sewage Master Control Centre. Critical alarms shall also be annunciated with flashing/strobe lights and audio sirens at select locations throughout the STP site. The Contractor shall submit full alarm schedule details including designation of critical alarms and annunciation locations for Engineer's review and approval prior to implementation.

13.19.2 Sewage Pump Station (SPS) and Head works

13.19.3 SPS Coarse Screens

Gravity sewage flow shall enter the inlet common channel of coarse screens. The high level switch in this channel shall initiate a coarse screen cleaning cycle, and both the high and high-high level switches shall generate an alarm.

Gates with manual hand wheel operators shall be installed both upstream and downstream of each coarse screen so that each screen channel can be isolated for maintenance.

The coarse screens shall be operable manually from a local control panel located adjacent to the equipment or remotely from the STP SCADA HMI. Remote operation shall be operator selectable as manual or auto. In auto mode, operation of the coarse screen rake mechanism shall be controlled by level differential with a timer override. Level elements shall be installed both upstream and downstream of the coarse screens. When the upstream minus downstream level differential reaches an operator specified maximum, a screen cleaning cycle shall be initiated. Alternatively, the operator may also specify a maximum interval between cleaning cycles. If this interval elapses without cleaning, a cleaning cycle shall be initiated regardless of level differential. The upstream and downstream levels shall be continuously monitored by ultrasonic type level sensors/transmitters.

Note- Automatic Jam Removal System shall be provided by the contractor for Coarse Screen.

13.19.4 SPS Coarse Screenings Conveyer

The screening conveyer shall operate in Auto mode in linkage with the coarse screens. The screening conveyer can be operated manually by the operator at a local control panel located adjacent to the equipment for trouble shooting or maintenance, or at the STP SCADA HMI.

Alarms/faults and status shall be monitored/logged and control commands shall be generated in accordance with the Engineer-approved I/O list.

13.19.5 SPS Pumps

The raw sewage enters the wet well after passing through the coarse screens.

All pumps shall be constant speed. Under normal operation one of the pumps shall be designated as working and the other as standby. Ultrasonic level elements as well as low, low-low, high, and high-high level switches shall be installed in each compartment of the wet well.

The pumps shall be operable manually at a local control panel located adjacent to the equipment or remotely at the STP SCADA HMI. Remote operation shall be operator selectable as auto or manual. In auto mode, sequencing shall be controlled based on wet well level. The operator shall be able to specify start and stop levels for each working pump. The working pump shall start first (at pump 1 Level). As wet well level rises, pump 1 shall be started at Pump1 level reaches. As the level continues to rise from start level for pump 1 to start level of pump 2, then pump 2 shall be started. If level continues to rise from start level of pump 2 to start level of pump 3, then pump 3 shall be started . The above sequencing shall be reversed for decreasing wet well level.

The above sequencing shall be reversed for decreasing wet well level.

An Electromagnetic type flow meter and Pressure Transmitter installed on the raw sewage pump discharge header shall measure and transmit the raw sewage flow & Pressure to the STP SCADA HMI.

Pressure gauges will be mounted on the discharge pipes of the sewage pumps for monitoring and alarming.

Note:- In Auto-mode, The Duty Rotation Logic shall be implemented with case to case basis for each Wet well Pump based on all defined Permissives along with Level Interlocks including Duty period of each pump and also the same shall be incorporated in Control Philosophy document for prior approval of Employer's representative. After getting approval of the Control Philosophy document Functional schematics shall be submitted by the contractor prior to Logics development in the PLC.

13.19 Headwork's at STP

13.20.1 Fine Screens

The raw sewage will be delivered to the fine screen inlet channel.

Gates with manual hand wheel operators shall be installed both upstream and downstream of the fine screens so that each screen channel can be isolated for maintenance.

The control and instrumentation philosophy for fine screens shall be similar to that for the coarse screens. In addition to the controls described for the coarse screens, the fine screens shall be equipped with flushing spray nozzles controlled by solenoid valves. The flushing valve shall open/close in the auto mode in linkage with the associated screen running condition. The fine screens can be operated manually by the operator at a local control panel located adjacent to the equipment during trouble shooting or maintenance. The flushing valve will also be operated manually by the operator at the above local control panel.

Removed screenings/debris will be washed prior to being disposed into the skip through belt conveyers.

Note- Automatic Jam Removal System shall be provided by the contractor for fine Screen.

13.20.2 Fine Screenings Conveyor

The conveyer shall operate in an auto mode in association with the medium screens. The conveyer will also be operated manually by the operator at the local control panel located adjacent to the equipment during trouble shooting or maintenance, or at the STP SCADA HMI.

13.20.3 Grit Collectors and Parshall Flume

The grit collectors will be installed in the grit basins to transport settled grit into a pit at the outer edge of the basins by a rotating scraper. The pit also serves as the bottom of the grit washer/classifier. The de-gritted sewage overflows to a partial flume and then to the Aeration basin inlet distribution structure. The sewage flow shall be measured continuously at the partial flume with an ultrasonic type level transmitter and a level-flow converter.

13.20.4 Grit Washers/Classifiers

The grit washers/classifiers shall be manually operable at the local control panel located adjacent to the equipment during troubleshooting or maintenance, or at the STP SCADA HMI. The flushing valves shall be manually operable at the local control panel located adjacent to the equipment during troubleshooting or maintenance, or at the STP SCADA HMI.

In auto mode, the grit washers/classifiers shall run continuously. The flushing valve shall open/close automatically in the auto mode in linkage with the grit washer/classifier.

13.20 Biological Treatment

13.21.1 SBR tank

The degritted sewage shall be conveyed to selector tank and subsequently to SBR tanks rectangular in shape for BOD and biological nutrient removal. The flow from splitter chamber shall enter the selector tank over inlet weirs made of stainless steel (SS: 304) and shall overflow over outlet weirs (SS: 304) into batch reactors. The weir plates shall be adjustable type and all fittings, fixtures, fasteners, nuts, bolts etc. shall be of stainless steel material (SS: 316). The selector tank shall be provided with required number and capacity submersible mixers to keep the tank contents under suspension. The

mixers shall be complete with lifting bracket, guide pipe, lifting chain, etc. complete. The tanks shall be provided with RCC platforms / access walkways all round. The walkways / stairways shall be protected with hand rails. PVC encapsulated CI rungs shall be provided for accessing the floor of the tanks. At one corner of the tank a drain pit shall be provided for emptying the tank contents during maintenance using portable submersible pump. The floor of the tank shall be sloped towards the drain pit through screed layer.

The sewage shall be further conveyed to SBR reactors. The flow shall enter over inlet weirs made of stainless steel (SS: 304). The weir plates shall be adjustable type and all fittings, fixtures, fasteners, nuts, bolts etc. shall be of stainless steel material (SS: 316). The reactors shall be provided with required number of diffusers. All the fasteners, nuts, bolts, clamps, hooks etc. for fixing the diffusers shall be of stainless steel material (SS: 316). The diffuser spacing inside the aeration tank shall be such that good mixing conditions and uniform aeration is achieved throughout the floor of the tank. The air headers above liquid level shall be of stainless steel (SS: 304) material and shall be run on RCC platforms / access walkways with minimum width of 1.20 m. The walkways / stairways shall be protected with hand rails. PVC encapsulated CI rungs shall be provided for accessing the floor of the tanks. The tanks shall be provided with online dissolved oxygen meters at two locations i.e. inlet and outlet for monitoring the D.O level in the aeration tank. The floor of the tanks shall be provided with a deep drain pit at one corner to facilitate emptying the tank contents using a portable submersible pump.

In order to pump MLSS into selector tanks and drawing excess sludge a pumping station shall be provided attached to SBR tanks for housing re-circulation pumps and excess sludge pumps. The pumping station shall be provided with required capacity and number vertical non clog sludge pumps. The rising main shall be provided with an electromagnetic flow meter with bypass arrangement to measure instantaneous and cumulative flows. The pumping station shall be equipped with necessary mechanical hoists for lifting, moving and lowering the pumps during maintenance. On suction side of the pumping station suitable size longitudinal drain shall be provided leading to a drain pit for conveying the spillages. Exhaust fan shall be provided for the pump house as per electrical requirement.

All the above tanks shall be provided with PVC encapsulated CI rungs for accessing the floor of the tanks near the drain pits. The tanks shall be provided with RCC access walkways protected with hand rail. The structure shall be provided with RCC staircase for accessing the top from finished ground level.

13.21.2 Sludge Pumps

The sludge pumps shall be manually controllable (start, stop, and speed) at a local control panel located adjacent to the equipment, at the VFD panel, or at the STP SCADA HMI.

Under normal operation, the primary sludge pumps shall be controlled by the PLC in remote auto mode. In remote auto mode, three operator-selectable sub-modes shall be provided for control of primary sludge flow to the gravity thickeners – CONTINUOUS, TIMED, and TOTALIZED.

In the CONTINUOUS mode, the pumps shall run continuously, with the speed of the pumps modulated using the VFD to maintain an operator-specified total flow rate set-point. The total flow rate set point shall be divided by the number of primary clarifiers in service to generate a flow rate set point per clarifier.

In the TIMED mode, the pump speed and sludge flow rate shall be controlled as in the CONTINUOUS mode. However, instead of running continuously, the pumps shall start and stop according to an operator-specified timer program. The operator shall have the option to specify a single timer program for all clarifiers or separate programs for each clarifier.

In the TOTALIZED mode, the pump speed and sludge flow rate shall be controlled as in the CONTINUOUS mode. However, instead of running continuously, the pumps shall start at an operator-

specified start time once per day and shall stop when an operator-specified total sludge volume has been pumped.

13.22 Treatment Process

13.22.1 Anaerobic, Anoxic, and SBR Mixers

For processes, under normal operation, the mixers shall run continuously in remote auto mode when the basins are in service.

All mixers shall be operable manually in the field at the local control panel for trouble-shooting and maintenance, or remotely at the STP SCADA HMI.

13.22.2 Process Air Blowers and Aeration Basin Air Flow Control Valves

Control and instrumentation philosophy is presented below separately for SBRs and processes other than SBRs. For SBRs, each SBR basin under aeration shall be served by one or more blowers dedicated to that basin alone for the duration of the aeration phase. In contrast, for processes other than SBRs, all blowers shall discharge to a common header which shall distribute the air flow between all operating aeration basins.

The process air blowers shall be operable manually at a local control panel located adjacent to the equipment, or remotely at the STP SCADA HMI. Remote operation shall be operator-selectable as MANUAL, AUTO, or CASCADE for all STP.

DO probe holders and cable connectors shall be provided at no fewer than four (4) locations in each aeration basin, to be reviewed and approved by Engineer based on Contractor's submittals. The operator shall have the option of using any one of these locations for each aeration basin, effectively generating a single DO signal per basin.

For simplicity, blower sequencing requirements specified below in terms of increases or decreases in blower motor speed are stated for PD blowers with VFDs. However, the same requirements shall apply to centrifugal blowers, with increasing speed for PD blowers being replaced by opening of inlet and discharge guide vanes (more open position, less resistance, more flow, and more power) for centrifugal blowers, and decreasing speed for PD blowers being replaced by closing of inlet and discharge guide vanes (less open position, more resistance, less flow, less power) for centrifugal blowers, regardless of whether or not such requirements for centrifugal blowers are explicitly stated.

13.22.3.1 AUTO and CASCADE Mode Controls

For processes in AUTO mode, a flow controller shall automatically modulate the air flow control valve to each aeration basin to maintain an operator-specified air flow rate set point for that basin.

In CASCADE mode, for each aeration basin, a DO controller shall generate a modulating signal that includes proportional, integral, and differential (PID) components of the DO error (the difference between an operator-specified DO set point and the measured DO) for that basin. This modulating signal shall be used to automatically generate a variable air flow rate set point. The flow controller shall automatically modulate the air flow control valve to each aeration basin to maintain the automatically generated variable air flow rate set point for that basin.

In both AUTO and CASCADE modes, the most open valve (MOV) control strategy shall be used to control the pressure in the process air blower common discharge header, which also serves as the common distribution header for the aeration basins. The MOV is defined as the aeration basin air flow control valve whose position is most open amongst all aeration basin flow control valves. An MOV position controller shall generate a modulating signal proportional to the MOV position error (the difference between an operator-specified MOV position set point and the measured MOV position). This modulating signal shall be used to automatically generate a variable header pressure set point. A

pressure controller shall automatically control blower sequencing and speed (in case of PD blowers) or sequencing and inlet and discharge guide vanes (in case of centrifugal blowers) to maintain the automatically generated variable header pressure set point.

Operator shall be able to specify a variable start sequence number for each blower. Blower 1 shall start first at minimum speed (PD blowers) or minimum open guide vane position (centrifugal blowers). Speed shall be gradually increased (PD) or guide vanes shall be gradually opened (centrifugal) until the measured header pressure reaches the variable header pressure set point. If the header pressure set point is not reached with Blower 1 at maximum speed (PD) or guide vanes at maximum open position (centrifugal), Blower 2 shall be started and both blowers shall be initially set to 50 percent speed (PD) or guide vanes shall be set to 50 percent open position and operation of both blowers shall be synchronized. The speed of both blowers shall be gradually increased (PD) or guide vanes shall be gradually opened (centrifugal) until the measured header pressure reaches the variable header pressure set point. This sequence shall be repeated with additional blowers until the variable header pressure set point is reached. At any given time, operation of all running blowers shall be synchronized.

The above blower sequencing shall be reversed to gradually reduce blower speed (centrifugal) or gradually close guide vanes (centrifugal) and sequentially stop running blowers if the variable header pressure set point falls below the measured header pressure.

13.22.3 Alum Solution Mixers

The alum solution mixers shall be operable manually in the field at the local control panel, or remotely at the STP SCADA HMI. No automatic operation shall be provided.

The solution levels shall be monitored locally as well as at the STP SCADA HMI, using ultrasonic type level transmitters. Low and high Magnetic type level switches shall also be provided and shall generate alarms. A hardwired interlock shall be provided to stop both the mixers as well as the alum pumps when the low level switch is activated and also to operate the solenoid valves accordingly by using the same level interlocks.

13.22.4Alum Dosing Pumps

Under normal operation, the alum dosing pumps shall run continuously in remote semi-auto mode once started by the operator. The operator shall start and stop alum dosing manually. Once dosing is started pump stroke length, speed and sequencing shall be controlled to maintain an operator specified alum dose based on plant influent flow rate.

The pumps shall be manually operable at the local control panel located adjacent to the equipment, or at the STP SCADA HMI.

13.22.5Alum Dispersion Rapid Mixer

Under normal operation, the alum dispersion rapid mixer shall run continuously in auto mode in linkage with the alum dosing pump.

The alum dispersion rapid mixer shall be manually operable at the local control panel located adjacent to the equipment, or at the STP SCADA HMI.

13.22.6Disc Cloth Media Filter

Complete functionality of the system component to be ensured

13.23 Disinfection

13.23.1 Chlorine Disinfection

Under normal operation, the chlorinators shall be controlled in remote auto mode. In remote auto mode, two operator-selectable sub-modes shall be provided – DOSE and ORP.

In DOSE mode, the chlorine gas flow control valves of the chlorinators shall be automatically modulated to maintain an operator-specified chlorine dose set point. The operator-specified set point shall be multiplied by the plant influent flow and divided by the number of chlorinators in service to generate chlorine mass flow rate set point per chlorinator.

In CASCADE mode, the Residual Chlorine error (difference between an operator-specified Dose set point and measured Residual Chlorine value) shall be used to generate a modulating signal. This modulating signal shall be used to automatically generate a variable chlorine dose set point. The chlorine gas flow control valves of the chlorinators shall be automatically modulated to maintain the automatically generated variable chlorine dose set point. The automatically generated variable set point shall be multiplied by the plant influent flow and divided by the number of chlorinators in service to generate chlorine mass flow rate set point per chlorinator.

The chlorinators shall be manually operable at the local control panel located adjacent to the equipment and at the STP SCADA HMI.

13.23.2 Chlorine Ejector

Under normal operation, the chlorine injector shall run continuously in remote auto mode in linkage with the chlorinators.

The chlorine injector shall be manually operable at the local control panel located adjacent to the equipment or at the STP SCADA HMI.

13.23.3 Deleted

13.24 Solid Processes

13.24.1 Sludge Thickener

Complete functionality of the system component to be ensured

13.24.2 Centrifuge Unit

Complete functionality of the system component to be ensured

13.24.3 Dry Polymer Feeder

Under normal operation, the dry polymer feeder shall be controlled automatically in remote semi-auto mode when initiated by the operator at a local control panel adjacent to the equipment. The feeder valve shall be automatically modulated to maintain an operator-specified volumetric dry polymer feed rate for operator-specified time duration. Dilution water flow control valves shall also be automatically modulated to maintain an operator-specified dilution water flow rate for the same duration as the dry polymer flow – in linkage with the dry polymer feeder. Both the dry polymer feeder valve and the dilution water valve shall be automatically closed either when the operator-specified time duration has elapsed, or the level in the polymer batch tank reaches an operator-specified high level, whichever occurs first.

The polymer feeder and the dilution water flow control valves shall be manually operable at the local control panel located adjacent to the equipment and remotely at the STP SCADA HMI.

13.24.4 Polymer Batch Tank Mixers

Under normal operation, the polymer batch tank mixers shall operate in remote auto mode. In auto mode, the mixers shall be automatically started when the tank level reaches an operator-specified minimum level and shall be automatically stopped when the tank level falls below the minimum level. The polymer batch tank mixers shall be manually operable in the field at the local control panel adjacent to the tanks and remotely at the STP SCADA HMI.

13.24.5 Polymer Metering Pumps

Under normal operation, the polymer metering pumps shall operate in remote auto mode. In auto mode, an operator-specified polymer dose set point shall be multiplied by the measured dewatering feed sludge flow rate and by an operator-specified sludge solids concentration and divided by an operator-specified polymer solution concentration to generate a polymer solution flow rate set point. The polymer metering pump stroke and speed shall be automatically controlled to maintain the system-generated polymer solution flow rate set point.

The polymer metering pumps shall be manually operable at the local control panel located adjacent to the equipment and remotely at the STP SCADA HMI.

13.24.6 Dewatered Sludge Conveyer

Under normal operation, the dewatered sludge conveyor shall operate in remote auto mode in linkage with the centrifuges. In auto mode, the conveyor shall be running when any of the centrifuges is running.

The dewatering sludge conveyor shall be manually operable at the local control panel adjacent to the equipment and remotely at the STP SCADA HMI.

13.24.7 Deleted

ABBREVIATIONS USED

AMF	Automatic Mains Failure
API	Application Program Interface
CCTV	Closed Circuit Television
COM/DCOM	Computer Object Model/ Distributed Computer Object Model
BDA	Bangalore Water Supply and Sewage Board
CPU	Central Processor Unit
SCADA	Supervisory Control and Data Acquisition System
DDE	Dynamic Data Exchange
DLP	Data Loss Prevention
DO	Dissolved Oxygen
EMCS	Electromagnetic Compatibility Society
FBD	Functional Block Diagram
FOC	Fibre Optic Cable
GPRS	General Packet Radio Service
GRP	Glass Reinforced Plastic
GSM	Global System for Mobile
HMI	Human Machine Interface
IEC	International Electro technical Commission
I/O	Input / Output
ISO	International Standards Organization
IT	Information Technology
LAN	Local Area Network
MIS	Management Information System
MLD	Million Litres per Day-

MUX	Multiplexer
OPC	OLE for Process Control
ORP	Oxidation Reduction Potential
OSI	Open Systems Interconnect
PLC	Programmable Logic Controller
TSPS	Terminal Sewage Pump Station
RAS	Returned Activated Sludge
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
STP	Sewage Treatment Plant
TCP/IP	Transmission Control Protocol/Internet Protocol
TE	Treated Effluent
VBA	Visual Basic for Applications
VFD/VSD	Variable Frequency Drive/ Variable Speed Drive
WAS	Waste Activated Sludge
Windows™	Microsoft Windows
XML	Extensible Markup Language

13.25 System Completeness

This section of specifications defines the particular requirements of Instrumentation and Control system to be installed at STP. For selection of field instruments and control system or anything related to instrumentation, the Contractor shall follow the specifications contained herein.

Being a Turn Key contract, irrespective of the detailed specifications of the respective items detailed in the various chapters of the tender specification, the Contractor shall be required to provide all the equipment, accessories, cabling, earthing, providing necessary transducers/sensors, system hardware/software, programming logic, interlocks, cabinets, panels etc. to achieve the functional requirements described in the Bid Document.. The **System completeness** will be the Bidder's responsibility.

Note:
In FAT all the field instruments & Automation systems shall be tested 100% under category-"A'. The description about category -"A' already mentioned in clause 14.1.2 of part-14.

13.26 PARTICULAR REQUIREMENTS FOR (PLC) & (SCADA/HMI) SYSTEM

General

This part covers the general & Particular requirements for the design, supply, installation, Inspection and testing of Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA/HMI) and associated plant and materials.

13.26.1 Related Sections

A. Part 7- General Instrumentation & Control Requirements

13.26.2 Applicable Standards

All equipment shall comply with all applicable national and local laws regulations and standards, in addition to those listed below:

A. ISO 9000 and 09004	-	Quality Systems
B. IEEE 587	-	Power Supply Surge Protection
C. IEC 61131-3	-	Programming Languages for Programmable Controllers.
D. IEC 61158-2	-	Communication Protocols

E. ISO 9075 (BS 6964)	-	Structured Query Language (SQL)
F. BS 5515	-	Documentation of Computer Based Systems
G. BS 7165	-	Recommendation for Achievement of Quality in Software
H. BS EN 50081	-	Electromagnetic Compatibility
I. ISO 3511	-	Process measurement control functions instrumentation symbolic representation.
J. ISO-OSI	-	7 Layer Communication Model
K. IEEE 472-1974	-	Surge protection.
L. IEC 61850	-	PLC sub-station automation protocol.
M. IEC 8705101	-	Modbus protocol conversion\

13.26.3 Statement of Compliance

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during the Bid submission, and FDS submission. Failure to do so will be treated as a non-responsive bid. Contractor should take note on the importance of this obligation.

13.26.4 Quality Assurance

A. The Manufacturers shall be operating under an accredited ISO 9001 or above Quality System.
B. Upgrades and improvements to the manufacturers standard system that are released before the expiration of the warranty period shall be supplied, installed and commissioned at no additional cost.

These shall include all hardware and software necessary to implement the upgrade.

13.26.5 Submittals

A. Functional Design Specification (FDS):

The Functional Design Specification (FDS) shall be submitted to the Engineer within 3 months on the award of the contract and approved before manufacture and purchasing commences. FDS document for STP shall be submitted within the time period indicated above. The system vendor and/or Contractor shall include the following material as a minimum:

a. Project Overview, design concept, criteria and system architecture
b. Description of the design and design criteria.
c. Details of associated equipment.
d. Datasheets of the proposed equipment.
e. Electrical Design Specifications
f. Quality Plan.
g. Outline of acceptance test procedures (FAT & SAT).
h. Implementation program for manufacture, installation and commissioning.
i. Manufacturers literature for each item of equipment supplied/proposed.
J. Detailed Plant screens (SCADA screens)
k. software architecture, etc..
Note: Contractor to note that no part approval of FDS will be accorded.FDS shall be submitted in full with all details as detailed above.

Drawings and Documentation:

All drawings of telemetry and instrumentation control and Automation (ICA) equipment shall be on A3 or A4 size sheets, with title blocks approved by the Engineer.

Signature of the Contractors authorized representative to indicate the drawings have been checked prior to submission.

The text of all drawings and documentation provided by the Contractor shall be in the English Language.

C. Contractor's Drawings:

The Contractor shall submit 3 (three) reproducible copies plus two photocopies of general and detailed dimensioned arrangement drawings, schematics and wiring diagrams of all major items of Plant, for the Engineer's approval Manufacture of an item of Plant shall not commence until the associated drawings have been approved in writing by the Engineer.

All modifications or revisions to drawings shall be clearly indicated and the revision reference changed.

Drawings affecting work by other disciplines shall be provided to the Engineer, within 6 weeks from the date of enterprise.

Drawings for electrical equipment shall include:

Manufacturer's general arrangement drawings for all items showing clearly the position of all cable glands and main components including, where appropriate, foundation plans, showing the position of all holes required for fixing bolts and cables etc.

Manufacturers' schematic diagrams and connection diagrams for all items showing all internal wiring and terminal connections, suitably referenced Connection diagrams shall include existing and proposed outgoing cable connections.

General layout of plant showing cable routing.

Block diagram showing all plant, cable runs and cable reference numbers.

Cable schedules giving full details of use, destinations, size and number of conductors, grade, class and length.

Layout of grounding facilities.

Proposed arrangements for cables laid below ground showing identification references, voltage, depth of laying, route and length, crossings with other services, location of any joints and position of ducts, with cross sectional arrangements.

The Contractor shall modify existing drawings to show the modifications. If suitable existing drawings are not available the Contractor shall provide drawings showing the modifications. Record Drawings: As part of the Works and before Taking Over, the Contractor shall provide and forward to the Engineer, a complete set of drawings comprising two original size permanent transparency and six paper prints, of all final drawings of the Works as installed, schematic wiring diagrams, panel wiring and connection diagrams, cable route diagrams and schedules and any other special drawings which have been prepared during the course of the Contract. The Contractor will also provide drawings on computer disk in AUTO CAD (Latest Version), for the modification and printing of drawings. Also all drawings have to converted in to PDF files and stored in the Engineers workstation.

D. Training Plan and Manuals:

As part of the Works and before beginning training, the Contractor shall submit to the Engineer, 6 copies of complete operating and maintenance instructions for the system, referring specifically to the Plant. The documents will also be presented on computer disk in Microsoft Office 2003/2007 Word or

latest version available for Windows software format. Each copy of the instructions shall be contained in a substantial binder.

These manuals shall include but not be limited to the following information:

a. Detailed descriptions of the Plant operation and control scheme.
b. Manufacturer's original operation and maintenance procedures.
c. Complete parts list for all items of the Plant.
d. Recommended spare parts list.
e. Detailed maintenance instructions for all items as necessary to maintain the items in good working order, including all step-by-step procedures for troubleshooting and fault correction.
f. Configuration of data base, reports, logs and screen displays.
g. Data communication interface standards and protocols.
h. FBD and control loop flow diagrams.
i. Programme user instruction for all software
j. The system shall provide on line, complete user documentation, including examples of how to operate the various modules within the system. The documentation must be in electronic format, HTML based with the ability to search for topics by keyword or search for specific text.

13.26.6 Site Conditions

A. Temperature and Humidity Range. The equipment shall be installed in an environment having a temperature range of 0 °C to 55 °C and a maximum relative humidity of 100 % (non condensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.

B. EMI/RFI Noise Immunity. The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal-borne interference.

C. Generated Interference. The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1or equivalent Indian Standard for noise emissions.

D. Coordination. The Contractor shall check with other trades to ensure that equipment and material can be installed in space provided. Provide other trades with information necessary for them to execute their work. Details on Drawings, which are specific regarding dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.
E. Sequencing. The Contractor shall make applications to the local telecommunications Service Provider for provision of communications and coordinate with the sub-contractor responsible for installation of power supply services under this contract. Applications shall be made in time to ensure services are available for installation and commissioning of the telemetry equipment.

13.26.7 Commissioning

A. The Contractor, the Engineer and any appropriate personnel of the Employer shall be present when the equipment or installation is tested & commissioned.
B. Commissioning shall include operating the equipment in a variety of modes and sequences to prove its satisfactory operation, prior to commencing the formal site inspection and testing.

13.27 AUTOMATION & SCADA SYSTEM COMPONENTS

13.27.1 Programmable Logic Controllers

STP

Programmable Logic Controllers (PLC) shall be provided in a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules of the same series of the CPU and communication interface.

PLC shall have the following attributes as a Hot-Standby Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible (OPC should be a built in feature of the software and hardware. No external software patch or hardware module is allowed) and shall be modular in construction, so as to be capable of future expansion without hardware modifications. PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be "off).

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions. Refer approved vendor list.

PLC System (Panel) should be housed in a dust free environment.

13.27.2 PLC Coding

The Contractor shall supply, install, program and commission the PLC using the PLC manufacturers recommended windows based PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation. **FBD shall be used for coding of PLC's**.

13.27.3 SCADA/HMI

General

The HMI shall be suitable for day to day operation by non-computer literate personnel in the monitoring and operation of the treatment works.

Human Machine Interfaces (HMI)

Human Machine Interface (HMI) shall be provided at Monitoring Room (local control room). The SCADA system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimization. The system will allow

operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities.
The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

The HMI shall be constructed to a high standard to provide a high profile feature and focal point for visitors to the Sewage Treatment Plant (STP)

SCADA/HMI system should be housed in an **air-conditioned environment**.

13.27.4 Approved Manufacturers List for Automation

SL. NO.	DESCRIPTION	MANUFACTURES/MAKES
1	Workstations , Servers	Dell, HP, Compaq etc.
2	Programmable Logic Controllers	Schneider Electric(Quantum Series), Siemens PLC(S7-400H series), Allan Bradley(Control Logix series), ABB(AC 800 M Series), Mitsubishi (Q 25 Series),GE(7Xi Series),Omron PLC(CS1 D Series), YOKOGAVA (CENTUM)
3	SCADA Programming Software	Intellution IFix, Wonderware, WIN CC V 6.2, RS View, Visio Citect, Iconics, CX-Supervisor V3, Fast Tools
4	GSM/GPRS Equipment	Motorola, GE, Seimens, GSV Microtek, DataRadio, Sheetal Wire-less Systems

In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following:

(i) Submit a letter from the manufacture of the each equipment mentioned above, that the makes mentioned in this document are un-available/not suitable..
(ii) Provide evidence from the manufacture of the proposed equipment and demonstrate that the makes are superior/Equivalent to the approved makes.
(iii) At least 3 successful installations commissioned in last 5 years before bid date and satisfactorily operating for at least one year before bid date

And the above qualities and requirements shall be demonstrated and evidenced by inspection of manufacturing units and successfully installed plants (End users) for the equipment's desired and successful operation and certification by the Employer/Engineer (BDA)/Representative.

13.27.5 Uninterruptible Power Supply (UPS)

The power for Programmable Logic Controllers (PLC), RIO panels PLC and Supervisory Control and Data Acquisition (SCADA/HMI) shall be derived from separate UPS.

The UPS provided shall be sized to provide sufficient power to maintain system functioning for a period of minimum **60 minutes,** in case of power failure.

The above feature should be demonstrated during Factory Acceptance Test (FAT) & Site Acceptance Test (SAT).

13.28 Particular Specifications

13.28.1 Scope of Specification

The purpose of this part of the Specification is to define the basic requirements for microprocessor-based, programmable logic controllers (PLC) integrated into control system and Supervisory Control and Data Acquisition System (SCADA) intended for Sewage Treatment Plant (STP)

13.28.2 Programmable Logic Controllers

(a) Design and Construction Requirements

STP PLC shall be provided as a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, simplex input/output (I/O) modules, communication interface modules and man-machine interface (HMI) required to perform the desired functions.

Each PLC shall have memory protected built in historical archiving/data logging of system alarms & events and process variables. Data logger shall be able to log data based on time or an event.PLC shall have enough memory allocated to allow 200,000 time and data stamped discrete and /or analog values to be archived. The historical archive shall allow the oldest data to roll off the system as memory is used keeping the 200,000 most current data points available. Process point time stamping frequency shall be selectable within the configuration software. It shall be possible for the archived data to be exported in CSV format allowing use with standard spreadsheet and data software applications

PLC shall have the following attributes as a Hot-Standby configuration.

- Carry out sequential logic implementation for operations of plant;
- Carry out computation and interfacing for data acquisition, data storage and retrieval;
- It shall accept downloaded program from a programmer;
- It shall have different functional modules to perform the desired functions;
- It shall scan the inputs in time cycles and update the status of its outputs.

(b) Dual redundant processors

The master station shall be provided with two identical central processors configured such that they operate in Hot-Standby mode.

Redundant system with hot back up redundancy feature should be built in the CPU. Software engineered hot backup systems are not acceptable. CPU should have the memory expansion capability up to 7 MB. Both the CPU's should have separate backplane and associated hardware for redundancy. CPU system should have built in WEB server

SCADA connectivity with the CPU will be on dual Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity is to be provided. PLC CPU and I/O modules, Communication Modules, Converters, Switches etc. shall be of the same logic family.

Failure to do adhere to the above will be treated as a non-responsive bid and lead to technical disqualification. Contractor should take note on the importance of this obligation.
The system shall be designed and implemented such that when the Main processor fails, the Standby one shall automatically take over. The changeover shall be seamless, smooth and without any time delay and shall not cause any disruption to the overall distributed control system and to the ongoing processes.

The PLC system shall be expandable (OPC Compatible) and shall be modular in construction, so as to capable of future expansion without hardware modifications.

A. The system hardware, application software and database shall be sized to accommodate a total of 50% increase in signal capacity and up to 100% increase in an individual zone.
B. Sufficient plug in modules shall be provided and wired to terminals ready to accept future signals of up to 10 % for each IO card
C. Each IO card shall be able to accept at least two more I/O cards without requiring replacement of, or additions to, the original equipment.
D. The system shall be modular and capable of integrating into a network wide Central SCADA Monitoring Centre (CSMC) proposed at BDA main office Kumara park west , Bengaluru. Or at main Administrative Centre DSKL @ Sector 1 Adequate references shall be provided to demonstrate similar installations by the manufacturer.

PLCs shall be microprocessor based. PLCs shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be "off").

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

The PLC shall have a field proven track record and shall be fully compatible with the proposed Central SCADA Monitoring Centre (CSMC) located at at BDA main office Kumara park west , Bengaluru. Or at main Administrative Centre DSKL @ Sector 1

Application logic programs shall be fully compliant with all five logic development methods detailed in IEC 61131-3. The PLC shall be powered by two independent sources provided by the UPS system and all internal operating supplies shall be derived from the UPS.

The power supplies, I/O, CPU and communication modules, switches and battery backup rates shall be monitored by the PLC and shall be available by report.

During the times of the battery discharge, the PLC shall initiate an orderly self shutdown and automatically restart on the main power restoration without the need for reloading or initiation of any kind.

The PLC shall comply with the specification specified elsewhere in this specification.

Each PLC shall have built in web server capability allowing system information to be stored in a format that allows for easy access and viewing with standard Windows based browser. Each unit shall be furnished with built in O & M data associated with its specific site including; as a minimum , basic system information, panel layouts, wiring diagrams, material lists w/part numbers, and operational summary. This information shall be accessible locally or remotely

(c) Central Processing Units

The central processing units (CPU) shall be a high performance processor with modular configuration suitable for real time process applications

The following additional features shall be provided.
Redundant system with Hot back up redundancy feature should be built in the CPU.

Software engineered hot backup system will not be not acceptable. CPU should have the memory expansion capability up to 7 MB.

Both the CPU's should have separate backplane and associated hardware for redundancy.

RIO's to have dual redundancy on network level connected to both the CPU. Even on the failure of one CPU backplane the other system should be available on dual network at RIO level.

SCADA connectivity with the CPU will be on dual Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity should be provided. Communication between CPU and peripherals shall be by an I/O bus. The individual device, interfaces shall be capable of being plugged into the I/O bus.

On resumption of power following a power failure the PLC shall automatically restart its controlling function.

CPU shall have a real time clock capability to accept a time synchronization pulse and adjust its internal clock with the pulse.

CPU shall have extensive self diagnostic facilities and watch dog timers to identify faults at card levels

(d) Memory Unit

Memory unit shall comprise of highly reliable memory chips which are industry standard, proven design with fast random access and suitable for operation in process environments. Main memory shall be modular and facility shall be provided for the upgrading and expansion of memory to meet future demands.

Not less than 50 % spare program memory and data memory space shall be provided. System initialization and application software shall be stored in EEPROM or EPROM. Operating data shall be stored in a RAM fitted with an internal battery backup. The battery backup provided shall support the memory on loss of power for at least one month. The battery life shall be at least 2 years.

(e) I/O Modules

Standard rack mounted plug in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU., Communication Modules, Converters, Switches etc. Deviation from this would be treated as a non responsive bid. Contractor should take note on the importance of this obligation. Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules should be hot swappable.

20% extra modules of installed capacity for each type of module shall be provided as spare. Provision shall be made for future expansion of additional 20% extra I/O modules of the installed capacity.

I/O modules shall be as follows:
- inputs shall be opto isolated.;
- filters shall be provided for noise rejection;
- output status shall be indicated by an LED;

- all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;
- all the modules shall be of addressable type.
- Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 BaseT connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

(f) Analogue Input Modules

They shall consist of an input isolation unit, signal conditioning unit and an analogue to digital converter (ADC). In addition, the following features shall be provided.

- cross talk attenuation
- provision for monitoring of the ADC for overflow detection
- gain amplifier with high common mode rejection ratio
- accuracy for analogue signals shall be 0.5%

(g) Digital Input Modules

The following design features shall be provided.

- contact bounce protection;
- choice of type of contacts.

(h) Digital Output Modules

The digital output module shall provide contact closure output by driving relays. The features to be provided are as follows:

- contact bounce protection shall be provided
- relay output shall be provided to operate pump motors and motorised valve actuators
- fail safe position in case of output module failure and fault indication

PLC's provided under this specification shall be capable of performing the necessary logic to control the system as previously defined. These capabilities shall include, but not be limited to the following:

1.	Discrete input/output	10	Latch/unlatch relays
2.	Analog input	11.	Counters
3.	Analog output	12.	Comparators
4.	Timers	13.	Ladder logic
5.	Pump Controller	14.	Flow Totalization/Integration
6.	Pump Alternation	15.	Intrusion Detection
7.	Mathematical Function Blocks	16.	Time of Day Control w/Lockout
8.	Stage Blocks	17.	Ramp Blocks
9.	Trending	18.	Data Logging

(i) PLC Programming

PLC programming shall be carried using FBD. The logic shall be prepared using proprietary programming software and shall be comprehensively annotated with subroutine and rung comments to assist further development and maintenance.

The system shall support a simple programming of the application software comply with IEC 61131-3.

The system shall support a structured, modular programming. At least the following standard operations shall be applicable:

(1) Logic functions (such as AND/OR/AND NOT etc.);
(2) Timer functions (externally adjustable);
(3) Counter functions;
(4) Skip functions;
(5) Comparison functions;
(6) Limit value functions;
(7) Arithmetic functions;
(8) Physical unit functions;
(9) Closed-loop functions such as P/PI/PID/etc.

The Contractor shall submit the logic diagrams for review. The Contractor shall include the as-built logic in the final submission.

(j) Programming Unit

The programming unit shall be of the portable type, industrial model designed to be used during commissioning on site. A functional keyboard which supports different type of programming methods shall be included, as well as a CRT or TFT display

At least the following functions shall be included:

(1) On-line programming
(2) Off-line programming
(3) Flexible corrections during input
(4) Full screen editing functions
(5) Absolute and symbolic programming
(6) Input of comments and title blocks for complete documentation
(7) Complete application software documentation functions. Printouts of application software logic functions shall preferably be in Ladder logic diagrams.
(8) Load and transfer functions

The computer shall be provided complete with proprietary PLC programming and SCADA software complete with plant mimics and documentation software. Communications cables required to interact with the PLC,(Eg: Modbus Cable) would be supplied by the contractor. The software shall provide facilities for:

- carrying out program revision management;
- insertion of comprehensive program subroutine and rung comments;
- search and find and search and replace 'contacts' and 'coils';
- simulation functions and testing of the program by changing the status of contacts and monitoring the outputs;
- preparation of coil and contact list and their locations and memory maps;
- make system backup copies while the system is online;
- upload and down load programs to the PLC on line;
- carry out on line maintenance and fault finding on the PLC.

13.28.3 Supervisory Control and Data Acquisition System (SCADA/HMI)

The SCADA shall be a fully integrated microprocessor based control and data acquisition system which will monitor, control, display, record and trend all assigned plant inputs and outputs. The SCADA shall be a fully dual redundant microprocessor based computer system such that reliable and automatic plant control can be achieved. The main process monitoring and control shall be by means of VDU based process operator workstations that shall be located in the central control room .

SCADA/HMI system would be **Dual Redundant server** system. The system shall be designed and implemented such that the failure of a central processor or HMI console does not inhibit continuous automatic control of the plant. In the event of such a failure, historical data shall be recoverable to a condition where a worst-case maximum of 15 minutes of historical data is lost.

Failure of a single outstation or communications to that outstation shall not effect control or operation of any other outstation, unless the failed outstation provides essential data to another outstation, in which case the non-failed outstations shall revert to a fail-safe mode.

An alarm shall be generated whenever a communications system failure occurs.

(ii) Hardware

The system shall support hardware and software interconnectivity to other networks generally in accordance with the ISO Open System Interconnect 7 layer reference model.

Computer:

1. The computer hardware shall be of current technology at the time of installation. Standard server stations, Standard PC technology with modern hardware, Windows operating system and data transmission over Industrial Ethernet must be used for the engineering workstations.

   It must be possible to install more than one engineering station in a system.

   The engineering system must be an open system that, for example, permits the importing of project data from Microsoft Excel, SQL or from CAD/CAE programs. It must be possible to import/export messages to/from Excel and Access for simple processing.

   Removable memory media must also be provided for each workstation.

   It must be possible to back up all database and configuration data both on removable media and on non-removable storage media without the system being offline.

   Provision of redundant storage media must be possible for the configuration database.

   The specs for computer hardware shown are indicative only. The contractor to select the appropriate hardware to suit the process requirements and data archiving.

   The computer shall, as a minimum comprise of a personal computer (PC) type architecture, with IBM compatible Pentium IV based system or better, capable of running a multi-tasking real time operating system suitable for process control applications:

2. All workstations, servers, communications equipment and peripherals shall be from reputed manufacturers, suitable for continuous operation and shall be the most currently available models at the time of construction, subject to approval. Adequate spare capacity shall be included to meet the specified requirements and future expansions.

3. The system shall support hardware and software interconnectivity to external Programmable Logic Controllers (PLC"s) over an RS-232/RS-485 serial data link using Profibus / Modbus, Ethernet or similar protocol, subject to the approval of the Engineer.

4. Data Storage:
   A historical data storage system with removable media for archive and backup will be provided. The data storage system shall store alarms and events, with the time of occurrence for one month and selected analogue signals connected to the system. All alarms and events shall be archived in a first in first out buffer, for a period of 40 days.

A high speed back up device with removable media, such as streaming tape cartridge or optical disk, shall be provided for each , suitable for backing up the whole system on a weekly basis.Data selected for archive shall be written to removable media which shall be sized to support at least 40 days worth of archive data.

At least one DVD write/rewrite/read with ±R and -R capacity in addition to the historical data storage device in the Engineering Station should be provided.

5. Visual Display Unit (VDU)

1. Visual Display Units (VDU's) shall be colour monitor screens, capable of displaying information in alphanumeric, bar histogram, graphical and mimic diagram formats. Monitors shall simultaneously display a minimum of 256 colours, non-interlaced, low radiation, flat screen with no discernible flicker. Display of characters shall be legible and stable on a shadow mask tube, having a resolution of not less that 1024 by 768 pixels and a refresh rate of not less than 70 Hz. The units shall include all the necessary picture controls to adjust the sharpness, contrast and position of the image. LCD VDUs shall be flat screen,. minimum requirements: brightness 250 cd/m2, 500:1 contrast ratio, 1600 x 1200 pixels,
2. VDU's shall be 32 inch.
3. VDU's shall be fitted with a power management system to reduce consumption upon detection of a stand-by signal from the PC.

6. Printers:

DeskJet:

Logging / Alarm / Report Printers – Continuous Feed:

1. Printers used for logging of system wide events and alarms shall comply with the following:-

Speed:

Print speed, black (draft quality mode)	Up to 21 ppm
Print speed, black (normal quality mode)	Up to 7.7 ppm
Print speed, black (best quality mode)	Up to 0.9 ppm
Print speed, color (best quality mode)	Up to 5 ppm
Print speed, color (draft mode)	Up to 15 ppm
Print speed, color (best quality mode)	Up to 0.9 ppm
Monthly volume (duty cycle):	5,000 pages **Print Quality & Technology:**
Print technology	Technology: Thermal Inkjet
Print quality, black	Up to 1200-rendered dpi black text
Print quality, color	Up to 4800 x 1200-optimized dpi color printing and 1200-input dpi
Resolution technology	PhotoREt III (PhotoREt IV-enabled)
Print cartridges	Color: Black, cyan, magenta, yellow
Ink types	Pigment-based, dye-based
	Memory & Print language:
Memory, std.	8 MB
Memory, max.	8 MB
Print languages, std.	PCL Level 3 Enhanced

Typefaces	8 built-in, 4 each in portrait and landscape orientations: CG Times, CG Times Italic; Univers, Univers Italic; Courier, Courier Italic; Letter Gothic, Letter Gothic Italic
	Paper handling:
Paper trays, std.	1
Paper trays, max.	2
Input capacity, std.	Up to 150 sheets
Input capacity, max.	Up to 150, up to 400 with optional 250-sheet paper tray sheets sheets
Standard envelope capacity	20 envelopes envelopes
Output capacity, std.	Up to 50 sheets
Output capacity, max.	Up to 50 sheets
Duplex printing (printing on both sides of paper)	Automatic (optional)
Media sizes, std.	Letter, legal, executive, cards, borderless media
Media sizes, custom	3 x 5 to 8.5 x 14 in
Media types	Paper (plain, inkjet, photo, banner), envelopes, transparencies, labels, cards, premium media, iron-on transfers, borderless media
Media weight, recommended	US letter: 16 to 24 lb, legal: 20 to 24 lb, banner: 16 to 24 lb, envelopes: 20 to 24 lb, cards: up to 110 lb index maximum, photo paper: up to 130 lb index
Media handling	Sheetfed
	Connectivity:
Connectivity, std.	IEEE 1284-Centronics parallel compatible, Universal Serial Bus
Connectivity, opt.	Jet direct external print servers
Macintosh compatible	Yes

7. Colour LaserJet Multifunction Printer:

Colour LaserJet Multifunction printer shall be used for the production of colour screen dumps and reports and shall have a sufficiently sized buffer memory such that system performance will not be degraded when the colour printer is operational and comply with the following:

Printer Specification:

All-in-one functions	Print, copy, scan, fax, stand alone scan-to email, photo card slots
Multitasking capability	Yes.
Print speed, black (normal quality mode)	Up to 21 ppm
Print speed, color (normal quality mode)	Up to 21 ppm
Print speed footnote	Exact speed varies depending on the system configuration, software program, and document complexity.
First page out (color)	As fast as 17.9 sec
Monthly duty cycle	Up to 40,000 pages

Footnote for duty cycle	Duty cycle is defined as the maximum number of pages per month of imaged output. This value provides a comparison of product robustness in relation to other LaserJet or Color LaserJet devices, and enables appropriate deployment of printers and MFPs to satisfy the demands of connected individuals or groups.
	Paper Heading:
Paper handling standard, input	50 sheet multi-purpose tray 1, 250-sheet input trays 2 and 3, 50-sheet ADF
Paper handling standard, output	150-sheet face-down output bin
Envelope capacity	Up to 30 envelopes
Envelope feeder	No
Duplex printing (printing on both sides of paper)	Automatic (standard)
Document finishing	Sheetfed
Media sizes, standard	Letter, legal, executive, envelopes (No. 10, Monarch)
Media sizes, custom	Tray 1: 3 x 5 to 8.5 x 14 in; Tray 2, Tray 3: 3.94 x 5.83 to 8.5 x 14 in
Media types	Paper (bond, brochure, colored, glossy, letterhead, photo, plain, preprinted, prepunched, recycled, rough), transparencies, labels, envelopes
Media weight	Tray 1: 16 to 47 lb (up to 58 lb with Color Laser glossy photo papers); tray 2, tray 3: 16 to 43 lb (up to 47 lb with postcards, up to 58 lb with Color Laser glossy photo papers)
Weight	71.2 lb
Processor speed	450 MHz
Memory, standard	160 MB
Memory, maximum	416 MB
	Scanner Specification:
Scanner type	Flatbed, ADF
Scan resolution, optical	Up to 1200 dpi
Bit depth	42-bit
Scan size, maximum (flatbed)	8.5 x 11.7 in
Scan size, maximum (ADF)	8.5 x 14 in
Scan speed (default)	Up to 15 ppm
Automatic paper sensor	No
	Copier Specification:
Copy speed (black, best quality, A4)	Up to 20 cpm
Copy speed black (best, letter)	Up to 20 cpm
Copy speed color (best, letter)	Up to 20 cpm
Copy resolution, black	Up to 600 x 600 dpi
Copy resolution, color	Up to 600 x 600 dpi

Copy reduce/enlarge settings	25 to 400%
Maximum number of copies	Up to 99 copies
	Fax Specification:
Faxing	Yes
Fax transmission speed (seconds per page)	3 sec per page
Fax memory	Up to 250 pages
Fax note	Based on standard ITU-T test image #1 at standard resolution. More complicated pages or higher resolution will take longer and use more memory.
Fax resolution, black (dots per inch)	Up to 203 x 196 dpi
Speed dials, maximum number	Up to 120 numbers
Auto redial	Yes
Fax delayed sending	Yes
Fax broadcast	119
Junk fax barrier	Yes
Polling	Yes (receive only)
Remote retrieval	No
Fax forwarding	Yes

13.28.4 System Overview

The SCADA/MMI system shall follow the International Standards Organization (ISO), Open Systems Interconnect (OSI), reference model guidelines. All central system hardware and software devices shall be interconnected using a bus topology data highway. The communications protocol used shall generally meet the requirements of the ISO.

The system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimisation. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers Terminal (ET), after successful log-on by security password.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

For each abnormal condition, Plant failure, Plant unavailable or failure to respond to a command within a given period, the MMI shall provide the appropriate alarm. Printed and archived alarms shall be time and date stamped for occurrence and acceptance. Alarms, logs and reports shall be output to separate printers. Alarms shall be in red. The ability to generate alarms within the system software based upon digital and / or analogue events and set points shall be provided.

An alarm horn with silence button shall be provided to alert the operator of an alarm condition.

Specific alarm, monitoring and control input / output requirements shall be determined from the particular control specifications and the Project Drawings.

SCADA/HMI system should be housed in **an air-conditioned environment**.

13.28.5 SCADA software functions

(a) General:

1. The Contractor shall be responsible for supplying complete software packages to enable the equipment to operate as stated in this specification. Provision must be made for the adding of further software tasks as and when required. All software functions shall be user friendly, with instruction and messages to aid the operator. The Contractor shall make available all standard software functions, even if not specifically detailed in the specification.
2. The computers shall utilize a real time multi-tasking and networked operating system with a proven track record in real time control applications.
3. The Operating System shall be Windows XP, loaded with MS-Office latest licensed version suitable for interconnection with external networks in a Wide Area Network (WAN) configuration, where specified.
4. The Application Software shall provide communication with other industrial standard open networks. The Software shall support Object Linked Embedding for Process Control (OPC).OPC should be a in-built feature of the software.

   The System shall support a fully distributed 64 bit Client/Server architecture.

   The System shall include Visual Basic for Applications (VBA) as a built-in programming language. Facility shall be available for building custom objects using VBA.

   Object oriented graphics and tools to easily build reusable control strategies.

   ODBC Application Program Interface (API) capable of collecting and writing secure real-time electronic records to one or more relational database.

   The software shall support OPC standards as both a client and a server for fast and reliable communications with a wide variety of hardware devices.

   Provide Active-X controls with selection of third-party Active-X controls for ready-made solutions without VBA programming.

   The SCADA software shall use SQL server as the integral database.

   A standard software package, such as Crystal Report shall be provided to facilitate generation of free format, intuitive and presentation quality reports.

   The Engineering Workstation shall be provided with simulation tools to support off-line testing of the control logics.

   The Server shall provide the master clock for the SCADA time synchronization.

   The system software shall be from the SCADA equipment manufacturer. Third party software is not acceptable.

   It is a requirement that the system be supported by on line configuration and editing of all VDU mimic displays and database and to create new displays and additional database.

   Operational mimics and other graphics shall be presented in an industry standard graphical user interface (GUI) format. A minimum of two active windows shall be displayable concurrently.

Both text and graphics shall resize automatically to accommodate changes made to the size of a window. The system shall be designed to minimize the operators use of the keyboard. All major functions shall be accessible on-screen through use of the mouse or track ball.
Operator system entry, for each area will be password coded with different levels of entry depending on the level of authority of the operator. Development and systems level entry passwords will be provided for engineering workstations. Each action taken by any operator at any level of entry, or at any operator terminal, shall be log file recorded and time and date stamped. Log in and out time and dates will be printed on the control room event logging printer.

VDU mimics will display dynamic color details of flow rates and pressures, pump status, well levels, alarms, electrical power supplies and other general equipment status conditions. All requests and commands shall be via icons, whether menu linked or linked to equipment control actions. A permanent dynamic alarm banner shall be displayed at the bottom or top of each operator screen. Each control action will be routed through a series of confirmation routines.

The reports shall be available for printing in graph or tabular format. Dynamic trend displays shall also be available for all analogue flow, level and pressure values. Custom, as well as preconfigured reports and trends shall be available to a higher level of entry. A colour, A4/A3 size, screen dump printer shall be provided for graph and trend prints.

An operator help utility shall be provided, offering help linked to the particular action being carried out by the operator at that time. At least one help screen per screen page shall be available. This facility shall be preconfigured with an option for updating by operators, via a password entry.

The Application Server software shall be configurable to provide for the monitoring and control of all points, loops, and systems through graphic display screens and hard copy reports. These shall include:

Parameter Displays for signal control
Control Loop Status Displays
Real Time and Historical Data Trend Displays
Event Displays and Log Reports
Alarm Displays and Log Reports
Equipment Diagnostic Displays and Reports.

The system shall provide on-line diagnostics that display the current status and operation of the local area network and its nodes. The diagnostic display shall include the LAN adapter status for the machine showing the display, as well as the current number of messages, errors and retries.

The system shall conform to and take advantage of industry standards. These shall include, but not be limited to:

ODBC
OLE
ActiveX
COM/DCOM
DDE and Advance DDE
C programming language
Visual Basic
Microsoft Windows XP or the most current Operating System
TCP/IP
OPC
XML

(b) Display Facilities

The displays shall be user configurable, with the user being able to construct any desired symbol for display. Any display shall appear (excluding historical recall) within 1 seconds to 3 seconds of

selection and the displayed data shall be updated from the database .Alarms shall typically appear within 3 seconds to 5 seconds of occurrence and within 1 second of being received into the central system database.
The Contractor shall configure all display pages as fully as possible. However, facility must be incorporated to permit easy construction and modification of the display pages, by using a standard library of shapes and symbols. The library shall be added to and modified by the user as required. The configuration shall be object orientated for ease of use.

The initial application software shall provide for the display pages listed below and any pages necessary for the system to function as a complete entity.

a. Mimic displays.
b. Graphic displays.
c. Trend displays.
d. Alarm summary tables with date and time.
e. Event logs of past 72 hours with date and time.
f. Tabular display of data.
g. Inset windows showing an analogue trends may be mixed with mimic displays. In such a display the main mimic and inset trend shall all be live with automatic display updates.

Indexing of information and menus shall be presented in the form of active windows on the screen, while the mimics etc. are still available for view.

No display or function shall effect the logging/monitoring of data. It shall be possible for the master station terminal and auxiliary terminals to perform simultaneously, different tasks within the display.

13.28.6 Monitoring and Alarms

1. The operator shall be able to monitor all of the information at the workstation. He shall be able to view active equipment information on a series of VDU based graphical and tabular displays.
2. In the event of an equipment alarm, the following shall occur at the master station:
   a. Alarm message displayed in the alarm message area of the screen.
   b. The audible alarm shall sound.
   c. The appropriate Section of the display page shall change colour and flash.
   d. A full message shall be written on the alarm page.
   e. The full alarm message shall be printed on the alarm printer.
   f. The full alarm message shall be recorded, stored on disk and automatically archived.
3. The operator should be able to acknowledge the alarm by pressing an accept alarm key or icon. This action shall stop flashing of all associated alarm messages and displays. However the display shall remain in the alarm state fixed colour to indicate an accepted alarm. When all outstanding alarms have been acknowledged the audible alarm shall be silenced.
4. Once the alarm has cleared, the messages and displays shall return to normal. The alarm message shall stay recorded on the event/alarm log and an alarm cleared message shall also be recorded.
5. If the alarm clears before being acknowledged the sequence of events shall continue as above except the message shall change to indicate a cleared alarm.
6. An audible alarm silence function shall be provided to enable an operator to silence the audible alarm without acknowledging all alarms. On occurrence of any subsequent alarm, the audible alarm shall sound.
7. Each signal within the configured system shall be capable of being assigned an alarm based on the following:
   a. Four levels per analogue (Lo Lo, Hi Hi, Lo and Hi).
   b. Rate of change.
   c. Deviation from set point or other control parameter.
8. Alarms shall be time tagged to 1 second resolution at the I/O's.
9. A minimum of four alarm priorities shall be provided so that those requiring immediate attention may be separated from alarms of lower priority. An audible alarm shall sound for alarms requiring operator action.

10. Typical alarm assignments are as follows:

a. critical alarm - - an alarm that requires immediate operator action
b. non critical alarm - an alarm that requires operator action but not necessarily immediate action
c. operator guide alarm - an alarm that provides information to the operator
d. event - a low priority condition which is recorded.

13.28.7 Data Archiving

Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable media system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes for a period of 15 months. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 75% full.

Analogues will be stored at a rate selected by the operator in the range 1 second to 1 hour. The operator shall have the facility to select the way in which an analogue is stored. The system will provide any combination of the following:

a. Instantaneous value.
b. Average value.
c. Maximum value.
d. Minimum value.
e. Not stored.

Maximum, minimum and average values shall be calculated over a period set by the operator in the range 15 minutes to 24 hours, the default shall be 1 hour.

The logging of new data and reception of alarms must be carried out at the same time as the operator is viewing archived data. Any alarms received must be displayed as an overlay on the visual display unit.

13.28.8 VDU Mimic Displays (SCADA Screens)

The Contractor shall configure all the mimics to provide total detailed coverage of the monitoring and control of equipment as detailed in this specification. It is expected that display modifications will be required in the future and therefore the ability to change the displays without programming skills is essential.

Instrumentation shall be displayed using ISO standard symbols. For mimic configuration, it shall be possible to call up a library of standard symbols representing items (e.g. pumps, valves) and add new symbols to the library. Building mimics shall be simple and be achieved by using a mouse or tracker ball pointing device. The mimic displays shall consist of the following pages:

a. A general diagram covering the whole of the system on a single screen with key data
b. A general block diagram for each site or area of Site showing the equipment displayed on a series of single screens with key data
c. Mimic of the equipment and instrumentation connected to each IO module displayed on as many screens as necessary.
d. Login screens, reports screen, security screen, overall STP screen, etc.. shall be configured.
e. SCADA screens shall include screens for TSPS under this contract.

13.28.9 Trend Displays

It shall be possible to plot dynamically updated real time data and archived data on a line graph, to represent analogue or digital information. Each graph shall be capable of displaying 8 plots overlaid on a graph of different colours and line texture. Next to the graph, there shall be a key relating each colour to its function. The horizontal axis shall be time based and user selectable in minutes, hours, days, weeks, for example, together with a start time.

The vertical axis shall be scaled as a percentage of range and be displayed in the colour of the selected reading. To avoid cluttering, the vertical axis scale shall be changed by selecting the individual display. The vertical axis shall be automatically scaled for each selected point, between limits entered by the user. Actual values in engineering units shall be displayed by positioning a cursor at the desired point of the trend graph.

The display of the data shall also be available in tabular form.

(a) Manual Data Entry:

1. The system shall be provided with facility for entering data manually via the keyboard. This data will fall into two types:

a. Constants which will be changed infrequently. This data may have time and date associated with it.
b. Maintenance related comments.

(b) Manually Corrected Data:

The system shall allow a person with authorized access to correct manually, erroneous data via the keyboard.

13.28.10 Reports

There shall be a real time spreadsheet facility supplied and installed by the Contractor in the master station. The users shall be able to transfer data from either the archive system or live data to the spreadsheet. The user shall be able to produce daily, weekly, monthly and annual reports using any data and a mixture of formats (tables, graphs, summaries, spreadsheets). It shall be possible to generate reports, either automatically at predetermined intervals, or manually on demand by the Operator. Typical reports on a minimum would be:

a. Flow rates and total.
b. Failures of equipment.
c. Analytical instrumentation parameters.
d. Wet well and tank levels.
e. Discharge pressures.
f. Maintenance schedules.
g. Process alarm conditions.
h. Chlorination equipment

13.28.11 Profiling

From an average, typical or manually entered plot, it shall be possible to set an exception profile whereby readings within an upper and lower level are acceptable. Profiles shall be set graphically via OW. The user may select for the system to alarm if the reading is outside the profile and highlight such exceptions as part of a report, thereby reducing the need to examine all data, to ensure acceptability. The number of exceptions shall be logged.

13.28.12 Data Manipulation:

It shall be possible to perform simple mathematical functions on any data, including the following functions:

a. Addition
b. Subtraction
c. Multiplication
d. Division
e. Square root

It shall be possible to log, display or use in a control loop, the resultant data.

13.28.13 Database Query Facilities:

The system shall support the use of database relationships and wild card characters to provide database query facilities. It shall be possible for applications integration to configure queries easily and save them for future use. Support of Dynamic Data Exchange (DDE) or Structured Query Language (SQL), to permit data exchange between the DCS and external applications, including spread sheets and databases.

Data shall be presented in tabular format and contain any combination of fields from the main system database. It shall be possible to manipulate the data by specifying search and sort criteria to define data range limits. Once a query table has been created, it shall be possible to store the configuration and initiate successive look-ups, using a point and shoot technique.

13.28.14 Downloading IO Configuration:

It shall be possible to download configuration to the IO's from the Engineer's terminal and the Portable Programming Unit (Laptop)

13.28.15Diagnostics:

The system shall have on-line diagnostic facilities to report system faults as they occur. A set of off-line diagnostic routines shall be supplied for more extensive fault diagnosis.

13.28.16 Security Access Levels:

The functions available on the system shall be fully flexible so as to allow user's access levels to be customised by the system operator, to suit individual user requirements.

Access to management and engineering levels shall be restricted by user selectable passwords or key switch. The security systems shall be based on a set of privileges, which may be granted or denied to individual uses by the system operator.

The security/access levels would be divided between engineers, supervisors and operators.

The system shall be protected from un-authorized changes to the operating system and application programs.

The system shall prevent un-authorized users from re-booting the system or aborting or suspending system-related programs.

The system shall provide three levels of operator access to the system as a minimum, with the first level permitting access to viewing selected plant conditions as described below and the highest level intended for the system manager.

A mechanism shall be provided which prevents users operating at a lower level from accessing functions assigned to a higher level.

The system shall provide a password-protected, user log-on facility for definition of the user access level. It shall be possible to define a minimum of eight privilege levels.

Passwords entered during the log-on process shall not be printed or displayed.
The software shall monitor the actions of the user currently logged on at each node and shall log the current user off after a definable extended period of no operator interaction with the system and produce a printed log-off message.

Logging off of the user shall not shut down the system.

System-generated log messages relating to operator actions, such as alarm acknowledgements or set-point changes, shall include the identification of the current logged-on user.

The Contractor shall provide the following defined user access levels as a minimum and additional levels as instructed by the Engineer:

1. **Default level**:
The default level shall permit users to view all displays except those specifically assigned to a higher level of access.

2. Operator level:

The operator level shall permit authorised users to access default level activities in addition to the following:
(a) Perform control actions;
(b) Acknowledge alarms;
(c) Enter or modify manually entered data for inclusion into reports.

3. **System manager level**:

The system manager level shall permit authorised users to access default level and operator level activities in addition to the following:

(a) Modify alarm and control set points, dead bands and time delays;
(b) Enter or modify historical data;
(c) Add, delete or modify individual I/O points or point attributes;
(d) Add, delete or modify field device configurations;
(e) Create, delete or modify control algorithms;
(f) Create, delete or modify graphic displays;
(g) Create, delete or modify system reports;
(h) Configure trend displays;
(j) Access the operating system;
(k) Assign access levels and user passwords;
(l) Perform any other system maintenance function

13.28.17 Programming:

The method of programming will depend upon the Manufacturers system requirements. However, the following standards shall be followed:

a. All programmes shall be written such that they lend themselves easily to alterations and additions.
b. Good programming practice shall be followed using structured programming techniques. All programmes shall be tidy in format and logical to follow. Programmes should be extensively annotated with comments and be self-documenting.
c. The system shall be supplied with programmes that use a high level language.

13.28.18 Programme – Documentation:

As part of the requirements of this specification full documentation is required as below:

a. Software user manuals
b. Database point allocation table
c. Complete program listing, flow charts for all sequences and control routines
d. Application software source code
e. End user license agreements.

13.28.19 LCD Screen

A LCD Screen shall provide an elementary full color pictorial flow diagram display of the treatment plant including points at which chemicals are injected. The mimic shall also include displays of process values e.g. Process flows, waste water quality etc. The mimic shall measure not less than 62" LCD Screen.

The operator interface shall provide facilities to:

- display status of devices associated with the process area concerned (i.e. running, stopped, fault etc.);
- display analogue values associated with that area of the plant;
- annunciate alarms associated with the area of the plant concerned;
- ;provide facilities for the operator to:
- silence the alarm (the alarm shall automatically silence after one minute (manually adjustable) if not manually silenced);
- acknowledge alarms
- select the duty drive of duty / standby drive pairs;
- adjust process set points;
- prompt process actions.

13.28.20 Private Automatic Branch Exchange (PABX) System for Connection to Public Switched Telephone Network (PSTN)

General:

The PABX system described in this specification shall have the following minimum features and facilities integrated into the system and ancillary equipment:

Scope:

This technical specification describes requirement of Private Automatic Branch Exchange (PABX) system connected to Public Switched Telephone Network (PSTN) and PABX to Exchange Telephone systems of Sub Treatment plant areas for STP.

Operating loop limits:

The system shall provide the following loop features:

- The extension line maximum loop resistance, including the resistance of the telephone shall not be less than 600 ohm.
- The trunk and tie line shall be capable of detecting a signalling current from the distant end, with the supply at a minimum of 45 volt.

Following Technical details along with Datasheets shall be submitted during Detailed Engineering.

(a) Whether the system can be equipped with duplicated controls and processor unit.
(b) What type of main processor/s will be supplied?
(c) Which components are duplicated, e.g. main memories, clock generator, switching network, multibus, signal unit, conference equipment, and voice mail?
(d) What the size of the main system memory is.
(e) What the dynamic traffic value is as specified in Busy Hour Call Attempts (BHCA).
(f) Whether the main processor can be upgraded to allow for a greater number of BHCA.

Features:

> DDI and DDO: The PABX system offered shall have Direct Dialling In (DDI) and Direct Dialling Out (DDO) facilities to be utilized to full advantage by the user to and from all extensions.
> The system will make provision for internal dialling.
> The baring of individual telephone extensions for STP at least 24 levels.
> Individual code baring will be possible (e.g. the baring of code 010) .
> The system will allow for conference.
> The system will make provision for call transfer.
> The system will make provision for Individual Speed Call.
> The system will have Inbuilt battery charger.
➢ The system will make provision for Code Looking of extensions.
➢ The system will make provision for Last Number Redial.
➢ The system will make provision for Call Hold.
➢ The system will support dial impulses analogue telephones.
➢ The system will support two (2) wire telephone systems.
➢ The system will have Fully Hybrid Ports.
➢ The system will have 32 party Conferencing and call budgeting features.
➢ The system will have Digital Architecture.
➢ The system will have scalability to 27 trunks and 72 Extensions.
➢ The system will have Automatic call distribution – (**ACD)** feature.
➢ The system will have Global and personal memory banks.
➢ The system will have a feature of Auto redial multiple numbers.
➢ The system will have account code feature.
➢ The system will have Listen in.
➢ The system will have STD Compatibility.
➢ The system will have a feature of Flexible station numbering.
➢ The system will be having a Key Telephone Instrument / Console.
➢ The Features of Key Telephone Instrument / Console as follows.
- KTS features include
- Hands free answering
- Full lit line key
- 06 programmable keys
- 2 line display
- 10 one touch keys

Earthing:

PABX system shall be installed at Central Control Room / Administrator Room, the contractor has to provide Earthing for PABX system from control room of Instrumentation control panel.

(i) Telephone Instruments:

The contractor shall supply, install, test and commission telephone instruments in- tended for use with the PABX installation for all indoor extensions, as well as those outdoor extensions which are included in the telephone schedule included else- where in the specification.

The contractor shall functionally check each telephone jack point, using a standard telephone instrument, for successful operation.

The PABX system must offer a choice of telephone instruments to meet the various requirements of the users. The telephone instruments should include:

(1) Basic analogue 2 wire connections.
(2) The system shall have the capability of handling telephone instruments with 16 digit keypads.

The tenderer shall define clearly in his tender every type of telephone instrument which may be used in conjunction with the system offered, as well as the type of analogue will be supplied, the facilities which each type of telephone offers and the cost of these instruments.

All telephone instruments shall be provided with a standard three-(3) metre connecting cable with a plug.

The tenderer must take note that the quantities of telephone instruments may be increased or decreased during the construction phase of this contract. The final contract sum will be adjusted accordingly.

Note:-
1) The contractor has to provide Trunk line protections for each line.
2) 2-Pair Cat-5 Cables along with Junction boxes shall be provided by the contractor for Connection to PABX system to each Extension Telephone Instrument systems.
3) If any items are required for PABX and PSTN, Contractor has to provide those Items as a Turnkey basis.
4) Contractor has to provide Telephone Land line Service for PABX system at STP.

13.28.21 Interface to the Jayanagar, Bengaluru Central SCADA Monitoring Centre (CSMC)

(a) General

Data from the treatment works is required to be passed to the at BDA main office Kumara park west , Bengaluru. Or at main Administrative Centre DSKL @ Sector 1. A redundant wireless GPRS gateway shall be used to transmit and receive the operational data to at BDA main office Kumara park west , Bengaluru. Or at main Administrative Centre DSKL @ Sector 1

(b) The Interface Panel

The interface shall comprise a redundant remote I/O module (RTU) /wireless GPRS gateway to be installed by the Contractor in the STP SCADA control room. The interface shall be housed in a control panel provided by the Contractor. The Contractor shall provide facilities to output from the treatment works control system via this control panel the discrete signals to be sent and to accept the discrete signals provided from the Central SCADA Monitoring Centre (CSMC).

Cabling between the interface control panel of the STP control system and the PLC of the STP control system will be carried out by the Contractor. The Contractor shall provide termination details to permit these connections to be carried out.

(c) Interoperability Test & Integration co-ordination:

The STP contractor shall conduct a interoperability test to confirm & demonstrate that the local control system data can be read & written by the at BDA main office Kumara park west , Bengaluru. Or at main Administrative Centre DSKL @ Sector 1 using appropriate OPC server & client software via the interface panel and local PLC/SCADA. The test shall be carried out in presence & co-ordination with the Central SCADA Monitoring Centre (CSMC) contractor/system integrator.

It is required that the local STP contractor maps his local I/O's for integration in the same format as required at at BDA main office Kumara park west , Bengaluru. Or at main Administrative Centre DSKL @ Sector 1

The STP contractor shall co-ordinate fully with the at BDA main office Kumara park west , Bengaluru. Or at main Administrative Centre DSKL @ Sector 1 contractor for integration tests .The STP contractor shall be fully responsible for data to be made available at at BDA main office Kumara park west , Bengaluru. Or at main Administrative Centre DSKL @ Sector 1

13.28.22 Control Room Furniture

In addition to the SCADA/HMI system equipment, the Contractor shall provide furniture (system console) to complement or match both the color and styling of the equipment. Control room furniture shall comply with relevant IEC standards for ergonomic design. Details of the control roomfurniture shall be submitted to the Engineer for approval.

The Contractor shall provide two fabric-covered upholstered swivel-type adjustable arm chairs with casters, a rigid and lockable steel cupboard for the storage of operating and maintenance manuals, drawings, logger paper, charts, disks and the like.

The visual display unit consoles or VDU desk shall incorporate at least one drawer unit with drawers for operators use and for standard files.

13.28.23 Spares For PLC and SCADA Component:

Contractor shall provide all the services and supplies in accordance with approved procedures for handling of spare parts, which shall include arranging for their proper receipt, stacking and storage.

(a) Spares for Commissioning & Start-up:

Contractor shall identify, define, procure, and supply construction, pre-commissioning, commissioning and start-up spares, special tools and handling gear for each item of equipment. On a minimum, 1PLC CPU, 1 DI Module,1 DO Module,1AI Module,1 AO Module, communication module(including wireless GPRS gateway) ,remote telemetry unit, fuses of each type and size installed.

(b) Spares list for 1st Year of Operation:

Contractor shall identify, define, procure, and supply construction, pre-commissioning, commissioning and start-up spares, special tools and handling gear for each item of equipment. These items and quantities should be subject to BDA"s approval. Upon completion of commissioning, contractor shall take inventory and ensure that spares for first year of operation as identified and defined are available on site.

(c) Spares List for subsequent 2 Years of Operation:

Contractor shall identify and define for the subsequent 2 years of operation, spare parts for each item of equipment.

(d) Spares List for subsequent years of operation

Contractor shall identify and define for the subsequent years of operation, spare parts for each item of equipment as necessary.

Note: Contractor to include Spare list during their bid submission based on the manufacturers recommendation for each item of equipment proposed.

13.28.24 Functional design specification for PLC and SCADA/MMI

The Contractor shall submit a complete functional design specification (FDS) for approval by the Engineer within 3 months of the award of the contract. Separate FDS shall be submitted for STP under this contract. This document shall serve as the primary mechanism by which the Engineer may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item.

The FDS shall describe the "fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence.

The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.

The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

The Contractor shall submit and obtain approval of the FDS from the Employer's Representative before beginning the detailed control system design. The contractor should take note of the importance of this obligation.

13.28.25 Submissions by the Contractor

The submissions by the Contractor pertaining to the PLC & SCADA System shall comprise the following as a minimum:

(a) A functional design specification (FDS) for the SCADA system. This shall be combined with the FDS for instrumentation, control and automation to form a complete document and shall comply with the specification of the FDS for instrumentation, control and automation. This document shall serve as the primary mechanism by which the Engineer may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain any necessary clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall include a detailed block diagram of the PLC & SCADA system with a description of the communications scheme to be provided. The FDS shall include operational details of the SCADA system which have an effect on plant operations, such as power failure response, communication failure response, and automatic shut-down and start-up of the system.

The FDS shall include a description of the interface of the SCADA system with any existing or planned future DAC equipment.

The FDS shall include a description of the interface of the SCADA system with the operational data management system software.

The Contractor shall submit a preliminary FDS and obtain approval before the system architecture design is finalized or detailed design takes place. The Contractor shall formally notify the Engineer for approval of any amendments or additions to the approved FDS. The final FDS shall be submitted

for approval before submission of the factory acceptance test definition documents. The Contractor should take note of the importance of this obligation.

(b) Layout drawings for each piece of equipment fabricated or assembled by the Contractor, showing the position of each component with required clearances where applicable, and with overall dimensions.
(c) Wiring diagrams indicating each component of the system and all wiring and cabling thereto, showing manufacturers, types, duties, ranges and nomenclature, referencing the P&I diagram where applicable, with inputs, outputs, cable wiring and terminal identifications clearly marked.
(d) Mimic video displays in the form of hard copies or photographs which are clearly legible and are notated to indicate dynamic data and control pick points where applicable.
(e) Control video displays in the form of hard copies or photographs which are clearly legible and are notated to indicate dynamic data and control pick points.
(f) Logic diagrams of plant operation and control system interaction (including modes of failure and shutdown routines).
(g) Complete input and output list giving type, circuit number, tag name, short description, outstation, database reference, associated field device, range (if applicable), critical/non-critical alarm status and the like.
(h) Description of quality control methods and approvals.
(i) Detailed works and acceptance test procedures.
(j) Programme for manufacture, delivery, installation and commissioning.
(k) Appendices, as necessary, to include manufacturer's literature for each item of equipment supplied.
(l) Operation and maintenance manuals detailing the following:
- General description and operating principles;
- Technical description of the equipment (manufacturer's standard brochures only being acceptable if the particular item of equipment described is clearly designated, adequate information is supplied, and irrelevant information is deleted or otherwise delineated)
- Complete operating instructions defining the sequence of operations, including flow charts;
- Procedures for dismantling, cleaning, servicing, replacing parts and reassembling, including recommended clearances and tolerances;
- Details of all instrument and equipment settings as applicable to this contract;
- Maintenance and lubrication schedules;
- Fault diagnosis procedures;
- Dated and priced list of significant spare parts and special tools, including identification numbers and sources of supply;
- Simplified arrangement drawings showing all components of the equipment.

(m) General operating manual comprising the following:
- General description and operating principles;
- Operating instructions for normal procedures in a step-by-step format including control operations, requirements for display or printing of data, performance monitoring, response to alarms or failures, changing of operational parameters, and manual data entry.

(n) System back-up software comprising the following:
- Application program software;
- Operating and utilities software;
- System configuration software including displays and operational plant data.

13.28.26 Software Documentation

The Contractor shall provide complete software documentation for each Programmable piece of equipment. The material to be provided shall include, as a minimum:

(a) All of the manufacturer's standard published reference materials and user's guides.
(b) Original of all licenses, the licenses shall have no restrictions and no Tag limitations (Un-Limited Tags). SCADA software will be of Un-limited TAG Version
(c) Complete documentation for any packaged software incorporated into the system including software written by other manufacturers.

(d) A working copy and complete documentation for any program-development software used for this project. This software and documentation shall be of the same version and revision numbers used for development under this contract.
(e) A working copy and complete documentation for any database management, report generation, screen graphic builder or other similar software used for development under this contract. This software and documentation shall be of the same version and revision numbers used for development under this contract.
(f) Hard-copy documentation of all configuration data, all user-accessible source code including control program code, reports and database contents including listings. All program listings shall be clearly and completely commented so as to convey to the reader a full understanding of the function of the program. So-called "self-documenting' code without additional, supplementary comments will not be acceptable.
(g) A complete input and output list giving type, circuit number, and tag name, short description, outstation, database reference, associated field device, range (if applicable), critical/non-critical alarm status and the like.
(h) A Software System Specification document which describes all control programs furnished with the system. Design documentation shall include, as a minimum:
- A description of the software development environment, including development procedures, limitations, restrictions, configuration management, documentation standards and compatibility;
- An overall description of the software design, including application structure and subsystem divisions, control strategy, monitoring and display hierarchy, data acquisition and storage, notational and operational conventions and operator access restrictions;
- A description of each application sub-system;
- A flow chart or "pseudo-code" description of each program module detailing the flow of control throughout the module;
- A list of files used by the system, including location and a brief description.

13.28.27 Drawings and schedules

The contractor has to submit the following set of drawings

(a) Process and instrumentation diagram
(b) General arrangement drawings of field-mounted instruments showing Installation details.
(c) General arrangement drawings of instrument and control panels, fully dimensioned
In plan and elevation views, showing foundation and fixing Details, access doors, clearances cable-entry positions, weight and lifting arrangement.
(d) Layout drawings of panel fascias showing instruments, controls and details of all labels.
(e) Layout drawings of panel interior showing equipment, terminal blocks and Cable ways.
(f) Annunciator arrangement and engraving details.
(g) Internal circuit and wiring diagrams for instrument and control panels.
(h) Schematic control diagrams.
(j) Instrument loop diagrams.
(k) Instrument wiring and piping diagrams.
(l) Interconnection wiring diagrams.
(m) Cable block diagrams, drawings and schedules.
(n) Instrument system and panel power distribution diagrams.
(p) Programmable-device functional design specifications which shall include Hardware details, logic flow charts, ladder diagrams and program listings.
(q) Schedules of inputs to and outputs from programmable controllers and Telemetry outstations.
(r) Labelling schedules.
(s) Comprehensive testing schedules for all off-site, on-site, pre-commissioning, Commissioning tests and take-over tests.

13.28.28 Uninterruptible Power Supply (UPS)

The UPS shall be floor mounted; self contained and metal clad and shall be suitable for supplying a non linear load.

It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact to touch.

The UPS shall be an on-line type incorporating a six pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch which shall operate in the event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply.

The UPS shall incorporate a dc under voltage trip circuit to electronically trip the UPS output in order to protect the batteries.

The noise level of the unit shall not exceed 60dB (A) at 1 m from the UPS cabinet.

The output of the inverter shall be a sine wave having less than 2% THD for linear loads and less than 4% for 50% non linear load. It shall be suitable for load power factors 0.7 lag to 0.9 lead.

The unit shall have a dynamic response such that a 100% step load causes an output voltage transient of less than ± 4% with a recovery time of less than 4 ms.

For three phase output units the output voltage shall not vary by more than ± 1% for an unbalance of 10%.

The load crest factor shall not be less than 3:1.

The efficiency at full load and 0.8 power factor shall be greater than 88%. Indicators to indicate
- UPS status
- UPS alarm conditions

The UPS shall provide a volt free contact output to indicate: warning, i.e. low battery capacity
- Fault
- Static bypass in use.

The UPS shall have an overload capacity of 150% for 30 seconds and shall be protected in the event of a short circuit of the output.

The batteries shall be housed, either within the UPS enclosure or within a separate matching battery cubicle suitable for location adjacent to the UPS.

Technical Particulars:

Each UPS shall have the following features:

a) The UPS shall be stand alone, parallel redundant, true on line, based on advanced IGBT PWM technology with microprocessor based control, monitoring and fault diagnostics, static by pass switch and front access oriented layout.
b) Main Parameters:

i. Input

Voltage	:	415V +10% -15 % A.C. Three phase 4 wires with Solidly earthed Neutral.
Symmetrical Short circuit level	:	25kA

Frequency		:	50Hz ± 5%
ii	Output		
	Voltage	:	415V ± 1% A.C, Three Phase 4 wire with Solidly Earthed Neutral.
	Frequency	:	5 0Hz ± 0.1Hz
	Wave form	:	True Sine Wave
iii	Isolation	:	True on line with complete galvanic Isolation
iv	Total harmonic Distribution	:	< 2% for linear load
		:	< 3% for non-linear load
v	Over Load Capacity	:	125% for 10 min 150% for 10 Sec
vi	Transient Response	:	Remain within ± 1% and recover to 100% within $^1/_4$ Cycle
vii	Crest factor	:	3 : 1
viii	Duty	:	Continuous
ix	Static by pass	:	to be provided
x	Efficiency		> 94%
	Converter	:	
	Inverter	:	> 93%
	Overall	:	> 87%
xi	Max Ambient Temp and Relative Humidity	:	45°C & 100%
xii	Cooling	:	Forced air
xiii	Acoustic Noise Level		<60db at 1.5m
xiv	Battery backup	:	60min for full load.

c) The UPS shall be complete with Isolation transformer, Converter cum Changer, inverter, protections, indications, programming, microprocessor based monitoring and fault diagnostic system, communication facilities, redundant control power supplies, SMF battery, accessories and interconnecting Cables.

d) Constructional Features: The UPS shall be high quality CRCA sheet steel enclosed suitable for floor mounting. The sheet steel shall be of 2mm thick. All sheet parts shall undergo phosphating process to ensure anti rust conditioning and superior finish. Premier quality powder coating shall be applied. The degree of protection shall be IP 54. The UPS panel shall be provided with two earthing terminals. The final finish shall be Light Grey Semi Glossy Shade 631 of IS 5.

Converter cum Charger:

When normal AC supply is available, DC power for the inverter is fully supplied by the converter and the battery is kept under float charge. On main supply failure, the battery shall be automatically connected to the Inverter without interrupting the output voltage for critical load. Similarly on normalization of AC power, the DC load shall be transferred to the converter and battery shall be put on float charge without interruption at output side. The converter cum charger shall be designed to deliver the full load DC required by the inverter and charging of the battery. Battery charging shall be with float & boost mode selection with current limit.

Inverter:

The static inverter shall convert the power from the converter/battery into stable AC power which is supplied to load. The inverter shall be with the latest IGBT PWM technology with specially designed output transformer.

Battery Bank:

Batteries shall be 12V, SMF (sealed maintenance free) type. The Qty & AH of batteries shall be suitable for backup period of 60 minutes for full load.

The battery shall be rated to provide full load power for required backup time on AC power failure. After delivering this amount of power, the battery shall be suitable for recharging through converter cum charger on AC power restoration. The battery shall be mounted on a separate rack. The battery bank shall be complete with battery stand, interlinks and UPS to battery interconnecting cable.

Other features:

The other features of UPS shall be as follows:

i) Micro processor based Control, monitoring and fault diagnostics.
ii) Comprehensive LED mimic and LED display with keypad Control to enable the following:
   a) Date-time stamped event recording and logging in a non-volatile memory
   b) Programming and Monitoring of various system parameters
   c) Status indications and number of LCD digital meters.
iii) 100% Non linear local handling Capability with low distortion of less than 5% and high crest factor of 3:1
iv) RS 232c/ RS 485 interface port.
v) Front access layout.
vi) Inbuilt line chokes for main power supply.
vii) Indications:
   - Mains 'ON'
   - Converter 'ON'
   - Inverter 'ON'
   - Battery Low
   - Over load
   - Inverter Trip
   - Charger Trip
   - Output 'ON'

viii)Protections:
   - Incomer MCCB with Overload & Short circuit releases
   - Outgoing MCCB with Overload & Short circuit releases
   - Battery MCCB with Overload & Short circuit releases
   - Input under/over voltage
   - Converter over voltage
   - Battery Low
   - Battery charging current limit
   - Output under voltage
   - Output over voltage
   - Output over load
   - Output short circuit
   - Inverter over temp
   - Single phase prevention

Alarm and trip conditions shall be separately annunciated.

The back up period shall be minimum 1 hr.

13.28.29 Uninterruptible Power Supplies (UPS) Testing

The Contractor shall carry out specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following on a minimum:

- change-over from full load with mains present to full load on battery supply;
- carry out a discharge test on the system at full load and for the specified duty bridging time period;
- carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.
- Demonstrate the full functioning of the PLC& SCADA system while running on UPS power.
- All Routine/acceptance tests as per relevant Indian / International standards shall be carried out in the presence of Employer / his Engineer

13.29 Quality Assurance/Quality Control (QA/QC)

QA/QVC shall comply with the Contract, with particular requirements specific to the equipment or service being provided as outlined below for PLC & SCADA systems. The quality assurance/control procedures shall include, but not be limited to the following:

- Continuity and Wiring tests;
- Insulation and High Potential Testing;
- Packaging and Shipping;
- Welding;
- Cleaning and Painting.

The quality assurance/quality control documentation shall include, but not be limited to the following:

- Material Certifications;
- Shop Test Reports;
- All other documentation required by applicable codes and standards.

13.30 Laptop Configuration details for Portable Programmable Unit(PPU) & Administrators Engineer's Usage:

• Operating system:	Latest operating system software that should be compatible with all Engineering Software's including Automation Software's.
• Processor:	Intel Core i7-3630QM (3.4 GHz/2.4 GHz)
• Processor speed:	3.4 GHz/2.4 GHz
• Processor technology:	Turbo Boost Technology
• Graphics:	2 GB GDDR5, up to 1.65 GB
• Memory:	8 GB DDR3
• Memory Slots:	2 DIMM
• Hard drive:	750 GB SATA (7200 rpm)
• Secondary hard drive:	Acceleration cache (32 GB Solid State Drive cache) with Intel Smart Response Technology
• Optical drive:	Blu-ray player/SuperMulti DVD burner
• Network interface:	10/100/1000 Gigabit Ethernet LAN

- Wireless: 802.11b/g/n; Bluetooth
- Power supply: 120W AC power adapter
- Battery: 9-cell (100WHr) Li-Ion
- Battery Backup time: Up to 5 hours and 45 minutes
- Number of Ports: 3 Super Speed USB 3.0; 1 USB 2.0; 1 HDMI; 1 VGA; 1 RJ45; 1 headphone-out; 1 microphone-in
- Expansion Slots: Multi-format digital media card reader
- Display: 17.3" diagonal full HD anti-glare LED-backlit
- Keyboard: Keyboard is required as per the standards of US English
- Audio: Beats Audio; 4 speakers; 1 subwoofer
- Wireless Mouse: Required

13.31 The Minimum Requirement for Instruments & Automation System Products.

Sr No	Instrumentation System	STP
1	Flow Measuring System: Electromagnetic Flow meters (for Measurement of Sewage Flow rate) & Ultrasonic Flow meters (for Measurement of Air Flow & Gas Flow rates) + Accessories +fittings (Refer T.S. clause No 7.12.2 and 13.4)	LS
2	Blower system Instruments (Instruments for Air Pressure & Air Temperature + Accessories + fittings (Refer T.S. clause No 13.7)	LS
3	Level Measuring System+ Accessories +fittings (Refer T.S. clause No 7.12.3 and13.10)	LS
4	Pressure Indicating Transmitters+ Accessories + fittings (Refer T.S. clause No and 7.12.4, 7.12.5 , 13.11 and 13.12)	LS
5	Pressure indicators/gauges+ Accessories + fittings (Refer T.S. clause No 7.12.4 and 13.11)	LS
6	Pressure & Flow Switches+ Accessories + fittings (Refer T.S. clause No and 13.11 and 13.11)	LS
7	Temperature-Measuring System + Accessories + fittings (Refer T.S. clause No 7.12.6 & 13.13)	LS
8	Junction Boxes & Field Enclosures (Refer T.S. clause No 7.9.5)	LS
9	Alarm Annunciators+ hooters+ Accessories + fittings (Refer T.S. clause No 7.9.2)	LS
10	Instrumentation Earthing (Refer T.S. clause No 7.8.11)	LS
11	Two & Three Position Selector Switches+ fittings(Including Electrical Accessories Like :-P.B's , LED's, MCB's e.t.c)	LS
12	Flow Integrator cum Totalizer+ fittings (Refer T.S. clause No 7.12.2 and 13.4)	LS
13	Panel mounted Digital Indicators+ fittings (Refer T.S. clause No 7.9.2)	LS
14	Temperature Scanner & Indicators+ fittings (Refer T.S. clause No 7.12.6)	LS
15	Surge Protection Devices +fittings (Refer T.S. clause No 7.12.9)	LS
16	Weight Indicator cum Transmitter+ Accessories + fittings (Refer T.S. clause No 13.12.2)	LS
	On-Line Analytical Instruments	
17	Dissolved Oxygen Analyzer+ Accessories +fittings (Refer T.S. clause No 13.14)	LS
18	ORP Analyzer+ Accessories +fittings (Refer T.S. clause No 13.14)	LS
19	Residual chlorine Analyzer+ Accessories +fittings (Refer T.S. clause No 13.14)	LS
20	PH Analyzer + Accessories +fittings	LS
21	H2S Analyzer + Accessories +fittings	LS
22	Hardness Analyzer+ Accessories +fittings	LS

Sr No	Instrumentation System	STP
22a	Online influent & effluent analyzer	LS
	Laboratory Instruments	
23	Refer clause No 13.15 and 13.16	LS
	Instrumentation Cables/cable trays	
24	Instrumentation (Analog) & Control Cables and Power Cables, OFC, Trays, Glands & Lugs, cable conduits (Refer T.S. clause No 7.10)	LS
25	Cable trays (Refer T.S. clause No 7.11)	LS
	Control System	
26	Liquid processes (Process Air Blowers)	LS
27	solid processes/sludge treatment (Centrifuge System)	LS
28	Chlorination	LS
29	Biogas Scrubber Package	LS
	Automation system(PLC based SCADA system) for STP	
30	Master (Redundant Hot Standby) & Slaves PLC Configuration Plant floor terminal (Refer T.S. clause No 13.26,13.27 & 13.28)	LS
31	Power supply modules for PLC CPU	LS
32	IO & Communication Modules	LS
33	RIO Modules along with Panels	LS
34	PLC Programming software	1
35	SCADA software(dual redundant configuration)	2
36	Historian software	1
37	Control Panels with Internal Wiring & Local Control Panels	LS
38	Surge Protection Devices	LS
39	Industrial Type Ethernet switches	LS
40	SMPS for Automation System	LS
41	commercial grade server PC's	LS
42	62" LCD Screen with accessories and Commercial Grade PC	1
43	Private Automatic Branch Exchange (PABX) System & No. of Extensions with Telephone Instruments	LS
44	Redundant RTU+ GSM/GPRS Communication modules along with Interface Panel for communication with MIS-2, SCADA center.	LS
45	Redundant FOC equipment +cabling +Insulated Pipes on conduits	LS
46	Laptop (PPU-1,Admin/Eng. Laptop-1)	2
47	System console/SCADA furniture	LS
48	Operator & Engineering work stations PC's	LS
49	Uninterruptable Power Supply	LS
50	Printers	2
51	Printer server	1
52	Interposing Relays with base terminal	LS
	Mandatory Spares to be supplied for Automation system(PLC based SCADA system) for STP	
53	CPU for PLC	1
54	Communication Module	1
55	Digital input module	1
56	Digital output module	1
57	Analog input module	1
58	Analog output module	1
59	Industrial Type Ethernet switch	1
60	Power supply module for PLC CPU	1

Sr No	Instrumentation System	STP
61	SMPS for Automation System	1
62	Remote RIO drop adapter	1
63	Wireless GPRS communication gateway	1
64	Remote terminal unit	1

Note: Any other item required but not covered as above.

End of Part 13

PART 14

INSPECTION, TESTING AND COMMISSIONING REQUIREMENTS

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PART 14

INSPECTION, TESTING AND COMMISSIONING REQUIREMENTS

14.1 Inspection and Testing During Manufacture

14.1.1 General

(a) All inspection and testing shall be carried out in accordance with the Specification and in absence of Specification relevant Indian Standard or internationally approved equivalent standard. After award of contract, Contractor shall furnish a QA plan for approval by Employer. QA plan shall include testing for incoming supply of raw materials and bought out items, stage inspections and tests on finished products at manufacturer's works / appropriate testing station. QA plan shall clearly indicate tests which are intended to be witnessed by the Contractor alone and those by both contractor and Employer.

(b) **Inspection and tests schedule shall be as follows;**
1) Manufacture tests
2) Acceptance inspection / Quantity checking
3) Install /site inspection
4) Site acceptance test
5) Tests on Completion
6) Process Wet Tests (by Raw Sewage)
7) Operation Test (Tests After Completion)
8) Complete performance tests of Plant after 03-year Operation & Maintainace (Before plant handing over)
9) Test furnished as per IS Code/manufacturer QAP

(c) The Contractor shall carry out at the place of manufacture tests of the Plant /Equipment at any part of the Works as per approved QAP.

(d) The Employer and/or duly authorised and designated representative(s) shall be entitled to attend the aforesaid inspection and/or tests.

(e) The Employer and his duly authorised representative shall have access to the Contractor's premises at all times to inspect and examine the material and workmanship of the mechanical and electrical plant and equipment during its manufacture there. If part of the plant and equipment is being manufactured on other premises, the Contractor shall obtain permission for the Employer or his duly authorised representative, to inspect as if the plant and equipment was manufactured on the Contractors own premises. Testing (including testing for chemical analysis and physical properties) shall be carried out by the Contractor and certificates submitted to the Engineer who will have the right to witness or inspect the above mentioned inspection /testing at any stage desired by him. Where inspection or testing is to be carried out at a subcontractor's works, a representative of the Contractor shall be present.

(f) Contractor shall provide test procedure, pre-factory test results, and calculation sheet, photo in advance and provide all of test result with necessary document including its data and photo to show Engineer that test is carried out in proper condition and the its test results. Construction material shall be tested by contractor at the approved laboratory

(g) The procedure for the testing and inspection to be carried out during or following the manufacture of the materials to ensure the quality and workmanship of the materials and to further ensure that they conform to the Contract in whatever place they are specified shall be as described below.

(i) The Contractor shall give the Employer at least 21 clear days notice in writing of the date and the place at which any plant or equipment will be ready for inspection/testing as provided in the Contract. Prior to notice, contractor should submit pre factory test results as per clause 14.1.1(f) The Employer or his duly authorised representative shall thereupon at his discretion notify the Contractor of his intention either to release such part of the plant and equipment upon receipt of works tests certificates or of his intention to inspect. The employer shall then give notice in writing to the Contractor, and attend at the place so named the said plant and

equipment which will be ready for inspection and/or testing. As and when any plant shall have passed the tests referred to in this section, the Engineer shall issue to the Contractor a notification to that effect after obtaining clearance from the consultants.

(ii) The Contractor shall forward to the Employer 6 duly certified copies of the test certificates along with characteristics performance curves/tables if any for all equipment obtaining dispatch clearance from the consultants/Engineer.

(iii) If the Engineer(s) fails to attend the inspection and/or test, or if it is agreed between the parties that the Engineer(s) shall not do so, then the Contractor may proceed with the inspection and/or test in the absence of the Engineer and provide the Employer with a certified report of the results thereof as per (ii) above.

(iv) If any materials or any part of the works fails to pass any inspection / test, the Contractor shall either rectify or replace such materials or part of the works and shall repeat the inspection and/or test upon giving a notice as per (i) above. Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Engineer before proceeding with further inspection of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be retested.

(v) Where the plant and equipment is a composite unit of several individual pieces manufactured in different places, it shall be assembled and tested as one complete working unit, at the manufacturer's works.

(vi) Neither the execution of an inspection test of materials or any part of the works, nor the attendance by the Engineer (s), nor the issue of any test certificate pursuant to (iii) above shall relieve the Contractor from his responsibilities under the Contract.

(vii) The test equipment, meters, instruments etc., used for testing shall be calibrated at recognised test laboratories at regular intervals and valid certificates shall be made available to the Engineers at the time of testing. The calibrating instrument used as standards shall be traceable to National/International standards. Calibration certificates or test instruments shall be produced from a recognised/Laboratory for the Engineer's consent in advance of testing and if necessary instruments shall be recalibrated or substituted before the commencement of the test.

(viii) Items of plant or control systems not covered by standards shall be tested in accordance with the details and program agreed between the Engineer and Contractor's Representative. If such materials or works are found to be defective or not conforming to the Contract requirements, due to the fault of the Contractor or his sub-contractors the Contractor shall defray all the expenses of such inspection and/or test and of satisfactory reconstruction.

(ix) Tests shall also be carried out such that due consideration is given to the Site conditions under which the equipment is required to function. The test certificates shall give all details of such tests.

(x) The Contractor shall establish and submit a detailed procedure for the inspection of materials or any part of the works to the Employer for approval within the date indicated in the Programme Details. The detailed procedure shall indicate or specify, without limitation, the following :

- Applicable code, standard, and regulations.
- Fabrication sequence flow chart indicating tests and inspection points.
- Detailed tests and inspection method, indicating the measuring apparatus to be used, items to be measured, calculation formula, etc.
- Acceptance criteria.
- Test report forms and required code certificates and data records.
- Method of sampling, if any sampling test to be conducted.
- Contractor's or Employer's witness points.

(xi) The Contractor shall not pack for shipment any part of the Plant until he has obtained from the Employer or his authorised representative his written approval to the release of such part for shipment after any tests required by the Contract have been completed to the Employer's satisfaction.

(xii) The following Inspection and Testing procedures shall be carried out for the equipment as per approved QAP.

The detailed procedure shall indicate or specify, without limitation, the following:

- Raw Material

- Visual Inspection/Appearance.
- Chemical and Mechanical property tests
- Dimension Checking
- Static & Dynamic balancing for all rotating parts
- Stage inspection
- Hydrostatic / Leak testing for all pressure parts, Pneumatic Leak Test wherever applicable
- Repair procedure
- Operation check
- Procedure Qualification Record (PQR); Welding Procedure Qualification (WPQ) and Welders Qualification Report (WQR)
- Material Test
- Assembly/Connection
- Documentation

(h) The Contractor shall maintain proper identification of all materials used, along with reports for all internal / stage inspection work carried out, based on the specific job requirement and or based on the datasheets / drawings / specifications.

(i) The expenses incurred during inspection shall include, but not be limited to all travelling, boarding, lodging and out-of- pocket expenses.

(1) The Contractor shall be responsible for all expenses incurred by the Engineer or person/s nominated by the Engineer in attending inspection and tests of Plant carried out during manufacture within India and abroad. Normally two or three persons from Employer side will witness the Inspection and testing along with the contractor's representative.

(2) Cost of inspection when material or any part of the facilities is not ready at the time specified by the Contractor for inspection or when re-inspection is necessitated by prior rejection shall also be borne by the Contractor.

(j) Witnessed testing will normally be waived on standard types of equipment such as small motors made by approved manufacturers, individual standardised instruments, small mass produced components used in the manufacture of Plant items, small bore pipework and fittings, minor installation materials and low voltage cable. In order to remove doubt this shall not relieve the Contractor of his obligation under the Contract to ensure that all Plant is tested at the manufacturer's works prior to delivery to Site.

(k) As a guide to the Contractor the Employer reserves the right to witness testing of the following but not limited to the following Plant items:

a) Electrical:

(1) Transformers
(2) 11 kV Metal enclosed switchboards & Switchgears.
(3) 415 V Metal enclosed switchgears (PCC)/ MCC
(4) 415 V Power capacitor and control panel
(5) Diesel Standby Generator with AMF Control Panel
(6) Battery, battery charger and DC Distribution Board
(7) Variable Frequency Drives
(8) Non Segregated Bus Duct
(9) Power & control cables
(10) Lighting System

b) Mechanical:

(1) Storage and process vessels
(2) STP Coarse/Fine Screens
(3) Grit Mechanism
(4) Chemical dosing systems complete with pumps, valves & tanks.
(5) Submersible Mixers, Alum dispersion mixers, Agitators, Screw/Lobe pumps, Submersible/Centrifugal Pumps and blowers including their motors.
(6) Valve and Sluice gate actuators.
(7) All type of Valves
(8) Pipes & fittings
(9) Sluice Gates

(10) Expansion/Dismantling Joints.
(11) Weir Gates & Stop logs.
(12) Fine Bubble Diffuser systems
(13) Chlorination system and Cl_2-Gas Scrubbers
(14) Disc Cloth Filter
(15) Sludge Thickener
(16) Centrifuge
(17) EOT Cranes and Hoists
(18) Belt Conveyor

c) Instrumentation and Control:

(1) Level Measuring System
(2) Pressure Gauges
(3) Pressure Transmitter
(4) Flow Measuring System
(5) DO analyzer
(6) ORP analyzer
(7) Temperature Measuring System
(8) Online Influent & Effluent Analyzer System
(9) Residual Chlorine Measuring System
(10) Instrumentation and Control Cables
(11) Instrument Control Panel
(12) Programmable Logic Controller
(13) SCADA / HMI System
(14) Uninterruptible Power Supply System
(15) Wireless GPRS gateway testing
(16) FAT & SAT for complete ICA system

(l) All destructively tested samples shall be replaced with new.

(m) The Employer reserves the right to be present during the testing and inspection of all Plant items.

14.1.2 Materials, Plant, and Equipment

The Contractor shall place orders for the material and the equipment only after approval QAP by the Engineer. The Contractor shall submit the detailed technical and its drawings from the approved manufacturer and the procedure of submission, review and revision shall be as specified herein below.

The Contractor shall inform the Employer about the likely dates of manufacturing, testing, and dispatching of any material and equipment to be incorporated into the Permanent Works. The Contractor shall notify the Employer for inspection and testing, at least twenty-eight (28) days prior to packing and shipping and shall supply the manufacturer's test results and quality control certificates.

The following inspection and test categories shall be applied prior to delivery of the equipment, of various categories as indicated in the technical specifications for each type of the equipment:

Category A: -The drawings have to be approved by the Engineer before manufacture and testing. The material has to be inspected by the Engineer or a third party inspecting agency approved by the Employer at the manufacturer's premise before packing and dispatching.

Category B: - The drawings of the equipment have to be submitted and approved by the Engineer prior to manufacture. The material has to be tested by the manufacturer and the manufacturer's test certificates are to be submitted and approved by the Engineer before dispatching of the equipment. Notwithstanding the above, the Employer, after examination of the test certificates, reserves the right to instruct the Contractor for retesting, if required, in the presence of the Contractor's representative.

Category C: - Samples of the materials and/or equipment shall be submitted to the Engineer for pre-construction review and approval in accordance with the provisions of Sub-Clause 5.5, Section 2. Following approval by the Employer, the material may be manufactured as per the approved standards and delivered to the Site.

For material/equipment under Category "A" and "B", the Employer will provide an authorization for packing and shipping after inspection.

The testing and approval for dispatching shall not absolve the Contractor from his obligations for satisfactory performance of the plant.

Dispatch Clearance

All mechanical/electrical/instrumentation equipment shall be tested at their respective factory which will be witnessed by tri parties (Contractor, BDA/Consultant inspecting team) in line with approved QAP and Equipment Data sheet.

The test observation sheets, material tests certificates (chemical and mechanical test at laboratory) and joint inspection report shall be signed by the Contractor, BDA/Consultant officials after successfully completion of tests.

Contractor shall forward all original reports to Bangalore Development Authority (BDA) and copy to Consultant for verification and issuances of Dispatch Clearance Certificates as per clause 14.1.1 g (ii). No Dispatch Clearance Certificate will be issued at the factory itself by the inspecting agency

14.1.3 Factory Acceptance Test (FAT) Document

Fifty six (56) days prior to commencement of inspection of each Plant item / equipment the Contractor shall supply a Factory Acceptance Test (FAT) Document for approval. This shall comprise four copies of the following:

- Unpriced copy of the Contractors order for the Plant item / equipment concerned:
- Details of the inspection and test procedures to be carried out.
- Pre-factory test results and its photos.

The FAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The FAT shall provide space within the documentation for results of the tests to be added and for each test and for the FAT as a whole to be signed off by the Contractor and the Engineer.

On completion of the tests the Contractor shall provide Six copies of all test certificates, curves etc. for the inspected Plant item. To remove doubt test certificates shall be provided for the Plant item as a whole plus certificates for the relevant component parts such as:

- Motors & Alternators;
- Storage and process vessels
- Coarse & Fine Screens Mechanism
- Grit Mechanism
- Chemical dosing systems complete with pumps, valves & tanks.
- Submersible Mixers, Alum dispersion mixers, Agitators, Screw/Lobe pumps, Submersible/ Centrifugal Pumps and blowers including their motors.
- Valve and Sluice gate actuators.
- All type of Valves
- Pipes & fittings
- Sluice Gates
- Expansion/Dismantling Joints.
- Weir Gates & Stop logs.
- Dewatering Centrifuge and associated plant
- Fine Bubble Diffuser systems,
- Decanter
- Chlorination system and Cl_2-Gas Scrubbers

- Disc Cloth filter Unit
- Sludge Thickener
- Centrifuge
- EOT Cranes and Hoists
- Instruments;
- Gear boxes;
- Electrical cables, switchgear & Transformers;
- Integral control and switchgear panels;
- Valve gear;
- Castings.
- Belt Conveyor

14.1.4 Inspection and Testing Programme

The Contractor shall submit to the Engineer not later than 56 days prior to the commencement of the first inspection and test during manufacture a programme detailing the inspection dates for all Plant. Those items of Plant that the Engineer has specifically identified for witness testing test shall be highlighted in the programme.
The Contractor shall keep the Engineer informed of any changes to the programme.

The Engineer shall not be requested to inspect an item of Plant until the Contractor has satisfied himself that the equipment meets all requirements of the Employer's Requirements.

The Contractor shall inform the Engineer in writing at least 21 days in advance regarding readiness for carrying out inspection of equipment/material etc. at manufacturer's works or at places of inspection. The programme for inspection shall be finalised by the Engineer after the receipt of the above case equipment/material etc. is found not to comply with the specification, dates for re-inspection shall be finalised and expenses incurred by the Employer for such visits shall also be recovered from the Contractor. Contractor's Representatives shall essentially be present during all inspections of Plant items. The following information shall be given in the inspection call letter mentioned above:

(a) Name of manufacturer/supplier;
(b) Address of place where inspection is to be carried out;
(c) Proposed date/s and equipment to be inspected;
(d) Name/s of contact personnel at manufacturer's/ supplier/s works with their telephone and fax numbers.
(e) Name of Contractor's Representative who will be present during the inspection.
(f) Confirmation that internal testing has been completed. Submission of internal testing report for review before visiting the plant

The Contractor shall provide all the necessary instruments, test facility, water / electric power, test piece, samples, engineers/ workers, all cost and others to carry out the tests after assembly. All instruments used for such tests shall be calibrated and certified by and approved by an independent testing authority not more than one month prior to the tests in which they are used. Calibration certificates with expire date and name of authorization agency for instruments used for such tests shall be produced for the approval of the Engineer and if necessary, instruments shall be recalibrated before the commencement of the tests.

No material shall be delivered to the Site without Dispatch clearance certificate having been carried out or waived in writing by the Engineer.

If during or after testing, any item of plant fails to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and retested and re-inspected as required by the Engineer.

All the equipments shall be inspected & tested with respect to the approved standards and norms at manufacturer's place.

14.1.5 Tests at Manufacturer's Premises – Mechanical Equipment

14.1.5.1 Sewage / Sludge Pumps

(a) All pumps shall be assembled completely in the shop to ensure correct fitting of all parts and shall be match-marked before shipment.
(b) All pumps shall undergo witness performance tests at the pump manufacturer's Works. Testing shall be undertaken with the respective job motor for all the pumps being supplied under the Contract.
(c) All tests such as Q/H curve, efficiency of pumps, power consumption, vibration and noise level shall be conducted, and NPSH tests one for each pumping station shall be undertaken to verify that the pumps meet the specified criteria. The pumps shall be run at constant flow capacity and speed.
(d) Pump casings shall be subject to hydrostatic pressure testing as an assembly at 150% of the pump shut-off head or 200% of the pump rated head whichever is higher. The hydrostatic pressure shall be held for not less than 30 minutes after all leaks have been stopped between attachments.
(e) Impeller and pump rotating assembly shall be dynamically balanced as per ISO 1940 / Gr. 6.3 / VDI 2060.
(f) Standard running test shall be conducted as per BS 5316 Part 2 Class B / ISO 3555 at the rated speed at manufacturer's works to measure the capacity, total head, efficiency and power. These tests shall form the basis for pump acceptance except for vibration and noise. The pump shall be tested over a range comprising shut off head to maximum flow. Minimum seven readings approximately equidistant shall be taken for plotting the performance curve.
(g) The following formula shall be taken for computing the power input to the pump:

Power input to the Pump in kW: $\frac{Q \times H \times 1.02}{367.2 \times p}$

Where, Q = Discharge in cum/hr
H = Total head in mwc
p = Efficiency of pump

(h) If the vibration, noise level readings taken during performance test show higher than that permitted, vendor shall guarantee to show that the values shall be maintained at site after erection. Any cost of rectification needed on this count shall be borne by the Contractor.
(i) Stage inspection for pumps shall be carried out as per approved QAP/ The Contractor has to make all necessary arrangement for witnessing the same.
(j) The efficiency quoted in the technical schedule shall be without negative tolerance.

14.1.5.2 Motors

(a) Routine Tests
All routine tests shall be carried out on all motors as per the latest edition of IS 325.

(b) Acceptance Tests
Full load test to determine efficiency, power factor and slip shall be conducted on all the motors.

(c) Type tests
The following type tests shall be carried out on one motor of each rating above 5 kW.

(1) Isolation resistance test
(2) Temperature rise test
(3) Momentary overload test
(4) Vibration measurement test
(5) Noise level test
(6) Over speed /over load test
(7) Starting current, starting torque, and pull out torque at reduced voltage

14.1.5.3 Valves and Expansion Joints

(a) During testing there shall be no visible evidence of structural damage to any of the valve component.
(b) Motorized valves shall be tested with their job actuator, with a differential head equivalent to their maximum working pressure, to prove that the actuators are capable of opening and closing the valves under maximum unbalanced head condition within the specified opening or closing period.
(c) Hydrostatically tested shall be as per relevant IS/BS standard for each type of valve.
(d) The following test shall be carried out for sluice, Plug, Ball and Knife Gate valves:
  (1) Seat leakage test.
  (2) Body hydrostatic test.
  (3) Valve operation.
  (4) Dimensional Check.
  (5) Visual Inspection.
(e) The following test shall be carried out for non-return valves:
(1) Seat leakage test.
(2) Body hydrostatic test.
(3) Valve operation
(4) Dimensional Check.
(5) Visual Inspection.
(d) The following test shall be carried out for Expansion Joints:
(1) Leakage test.
(2) Body hydrostatic test.
(3) Displacement range.
(4) Dimensional Check.
(5) Visual Inspection.

14.1.5.4 Pipe-work

Testing of pipes and fitting shall be carried out in accordance with relevant Indian Standard and internationally approved standard. Pipes, fittings and expansion bellows shall be hydrostatically tested for 1.5 times the rated pressure.

The following test shall be carried out for pipelines:

(1) Pressure test
(2) Leakage test
(3) LP test for welding pipeline
(4) Welding beat check
(5) Dimensional Check
(6) Visual Inspection

14.1.5.5 Compressors and Blowers

Tests shall be carried out in accordance with the relevant international standard. All compressors and blowers shall be tested with their ancillaries to confirm design performance particularly in respect of flow and pressure. The test shall demonstrate that vibration and noise are within the specified limits and that the pressure relief valve operates correctly.

Air receiver shall be tested in accordance with the relevant section of B.S. 5169.

All pressure vessels shall be inspected and hydro water tightness tested. Test will be conducted with Job Motors at Compressors/Blowers manufactures place

14.1.5.6 Process Plant Items

All process plant items shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction, and performance at the place desired by client

14.1.5.7 Crane & Hoists

The cranes shall be completely assembled in the Contractor's or subcontractor's Works and shall be subjected to the tests as specified in IS 807/IS 3177 or relevant internationally approved standard. The Contractor shall provide the test weights.

Hoists and lifting equipment shall be assembled and tested at the place of manufacture in accordance with IS 3938.

Each and every rotating part/assembly/sub-assembly shall be dynamically balanced as per grade G16 of ISO 1940/1 - 1986.

14.1.5.8 Sluice Gates

(a) Seat Clearance Check
With the gate fully closed, the clearance between seating faces when checked with the filler gauge, shall not exceed 0.1 mm.

(b) Movement Tests
Each gate shall be shop operated Manually/Electrically three times from the fully open position to the fully closed position and return to fully open, under no flow conditions to demonstrate that the assembly is workable.

(c) Leakage Tests
With the gate in closed position design pressure shall be applied for a period not lesser than 5 minutes to the unseating side of the sluice gate and the leakage shall not exceed the maximum leakage permissible as per IS 13349.

(d) Hydrostatic Tests
Finally a differential of one and a half times the design pressure shall be applied to the unseating side of the gate. Under these tests no part shall show any deflection of deformation.

14.1.5.9 Coarse and Fine Screens

(a) All screens shall be checked for overall dimensions, assembly, and clearance between the bars / space between a rake and bar surface / aperture size and its material as well as painting works. Moreover, motion of rake/drum and wiper/self cleaning arrangement shall also be tested at works
(b) Conveyor shall be checked for dimensions and physical conditions, belt joint portion, travelling accuracy of belt, motors and its power consumption, performance of safety device.
(c) At least one screen of each type shall be tested for efficiency and operation by employing screenings. For the screen having depth of channel more than 3 metres, testing with reduced depth is acceptable.

14.1.5.10 Fine Bubble Diffusers

(a) Clean water Standard Oxygen Transfer Efficiency (SOTE) tests shall be performed for each different diffuser grid geometry/arrangement proposed in the design. These tests shall be performed by the diffuser Manufacturer at the Manufacturer's testing facility or an equivalent facility appropriately equipped with an adequately sized testing tank and other required appurtenances. The testing shall be performed in full compliance with the latest version of the applicable standard testing protocol. These tests shall be witnessed by Engineer per procedures set forth for witnessing elsewhere in this document.

(b) All diffusers including 5 % spares shall be thoroughly inspected by Contractor for physical damage to the membrane or any other part of the diffuser and results of the inspection shall be reported to Engineer.

14.2 Field test

The test will verify the installation as well as the diffuser's ability to deliver the specified air flow rates at the manufacturer's stated pressure loss. Testing will also verify the uniformity of mixing provided.

Leveling tests:
1. Introduce clear water into each tank to the top of the diffuser elements.
2. Check the level of the diffusers to verify that all element horizontal surfaces are within 10 mm of a common horizontal plane and at the specified elevation.

Leakage and distribution of flow tests:
1. After successful completion of the leveling tests, raise the water level to 50mm above the manifold.
2. Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.
3. Repair any leaks in the elements holders, elements, pipes or the like.
4. Repeat the test until the installation is essentially void of air leaks.

14.3 Reinforced Cement Concrete Pipes Testing

(1) All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.
(2) Contractor shall provide laboratory test /analysis results of cement and aggregate component and cement vs. aggregate vs. water mixing ratio and concrete mixing time and mixing method.
(3) During manufacture, tests on concrete shall be carried out as per IS:456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS:458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.
(4) The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS:458 and tests in accordance with the methods described in IS:3597.
    (1) Hydrostatic test
    (2) Three edge bearing test
    (3) Absorption test
    (4) Dimension and colour of surface
    (5) Damage

Sampling and Inspection

(1) In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.
(2) The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS:458.
(3) Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every r-th pipe be selected till the requisite

number is obtained, r being the integral part of N/n where N is the lot size and n is the sample size.

(4) All pipes selected shall be inspected for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

(5) The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

(6) A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

(7) The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS:458.

(8) All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

(9) In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

(10) All destructively tested samples shall be replaced to new.

14.4 Steel Cylinders Pipes and Specials Testing

a) Welding beat check Remove all scale on the welding points and welding beat and its thickness shall be checked by the Engineer.

b) Penetration Test
A suitable penetrating liquid (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrating time, the excess penetrate, which remains on the surface is removed. Then a light coloured powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrate which had previously seeped into the surface openings. As the penetrate is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

c) Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

d) Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Engineer, the unlined specials shall be tested by penetration test as per IS:3658 or other approved means.

e) The contractor has to submit QA/QC and methodology for welding works

f) Approval of welding rods

g) Welders qualification Test

14.5 Cast Iron / Ductile Iron Pipes

Mechanical Tests

Mechanical chemical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

Brinell hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

Hydrostatic test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

14.6 Chlorination and Gas pipeline system

(a) All items of plant shall be tested at manufacturer's works and test certificates shall be provided.
(b) All chlorine gas piping from chlorine drums to chlorinator shall be pressure tested with dry air/nitrogen to a pressure of 15 kg/sq.cm.
(c) The chlorine gas piping from the chlorinators up to injectors shall be pressure/vacuum tested with dry air/nitrogen to a pressure/vacuum equal to 1.5 times the maximum pressure/vacuum to be encountered during operation.
(d) The motive water piping shall be hydrostatically tested for a pressure of 1.5 times the operating pressure or the maximum pump discharge pressure at pump shut off whichever is higher.
(e) After the chlorine system has been completely tested as above leak tests shall be conducted admitting chlorine gas. Leakages if any shall be identified using ammonia stick. During this test all chlorine leak detectors shall be in place and all safety procedures shall be adhered to.
(f) Gas cylinder shall provide the pressure test certificate issued by authority and manufacture year.
(g) Chlorine gas detector sensors shall be tested, and results shall provide to the Engineer.
(h) Ventilation system :
The ventilation fans shall be tested at manufacturer's works to verify the design flow and pressure.
(i) Process Plant Items;
All process plant items shall be tested to ensure they meet the Employer's Requirements for inlet and outlet quality of workmanship, construction and system performance.

14.7 Power Generator:

14.7.1 Power Generator (50Hz)

The power generator shall be tested by assembled system with engines. Test shall be carried on after at least 10 hrs in a continuous Engine and Power Generator operating time under normal operation including idling adjustment.

Contractor shall provide the test procedure in advance.

The results shall be evaluated by calculated and measurement data to verify whether all data is cover the specification or not at manufacture.

Work shall include but not necessary be limited to the following;

(1) Normal: 90%-100% load.
(2) Load change test:115%
(3) No load test: 0%

Scope of supply shall include Generator set and cogeneration system.

Inspection Work shall include but not necessarily be limited to the following;

a) Quantity checking
b) Power generator model /Type
c) Isolation method
d) Level of humidity (room)
e) Appurtenances
f) Spare parts
a) Appearance test
b) Dimensions.
c) Weight
d) Performance test
    (1) Fluctuation of motor temperature.(room air and motor)
    (2) Motor speed (rpm)
    (3) Power factor
    (4) Voltage drop(Max, Total)
    (5) Insulation resistance
    (6) Power generation efficiency
    (7) Amount of generated electric.
    (8) Performance of follow suit and stability.
    (9) Over load test
    (10) Acceleration test
    (11) Wavelength stability.
    (12) Performance of Quick over load test.
e) Emergency stop
f) Noise level (db)
g) Vibration
h) Control panel
i) Performance of Appurtenances (Battery, solenoid valves)

14.7.2 Disc Cloth Filter, Centrifuge, Sludge Thickener

The equipments shall be tested by assembled system with engines. Test shall be carried on after at least 10 hrs in a continuous Engine and Power Generator operating time under normal operation including idling adjustment.

Contractor shall provide the test procedure in advance.

The results shall be evaluated by calculated and measurement data to verify whether all data is cover the specification or not at manufacture.

14.8 Mechanical equipment

All mechanical equipment shall be tested at site as following items in bellow,

(a) The test will be verified any damage/missing part, No. of equipment to be installed, material, location as specified in drawing, levelling, centreline, solid installation and condition of installation to be fit in levelling of pipeline and valves.
(b) Testing run will be conducted for verifying rotation direction, vibration, noise, and stability and any leakage, if possible.
(c) The test will be verified to check maintenance space and ease of equipment maintenance work.
(d) The testing shall be performed in full compliance with the latest version of the applicable standard testing protocol. These tests shall be witnessed by Engineer per procedures set forth for witnessing elsewhere in this document.

14.9 Tests at site

(a) In addition to the progressive supervision and inspection by Engineer, the Contractor shall offer for inspection to Engineer, the completely erected plant/part of Plant on which tests are to be carried out. After such inspection, each equipment/sub-system shall be tested by the Contractor in accordance with the applicable standards in the presence of Engineer. Such tests shall include but not be limited to the tests specified in following clauses.

(b) The Contractor shall possess during the entire working period the Electrical Contractor's licence of appropriate class from the concerned statutory authorities governing the area of work place. The Contractor shall fully comply with the relevant statutory rules and regulations. On completion of the installation or at intermediate stages, if required by the statutory authorities, the Contractor shall arrange for inspection and obtain the approval from the concerned statutory authorities. If any fees are to be paid to statutory authorities for testing, inspection and calibration these shall be paid by the Contractor and shall be included in his erection and commissioning charges.

14.10 Pumps, piping and valves

(a) The erected pipe work shall be subjected to a hydraulic test at 1.5 times the maximum pressure or twice the working pressure whichever is higher to test the soundness of the joints. Provision of the necessary pumps, gauges, blank flanges, tapings etc. for carrying out these tests shall be included in the Contract. All gas piping shall be air tested to twice normal working pressure.

(b) Leakage tests shall be carried out on all erected pipe work, pumps and valves immediately after erection and where possible before being built in.

(c) Operating tests shall be conducted on valves.

(d) The pump set shall be tested for satisfactory operation. The vibration and noise level shall be checked to be within the specified limits.

14.11 Motors

Condition of winding insulation be tested and insulation values shall be restored to required level by suitable heating arrangements locally.

14.12 Cranes

The crane and lifting tackle shall be tested to 125 % of the safe working load. The Contractor shall arrange the test load. The contractor shall also arrange for the appropriate certificates from the concerned authorities before regular use of the cranes and other lifting equipment.

14.13 Screens

After erection, all screens screen shall be tested for smooth operation and capability to handle typical wastewater solids including stringy materials. Clearance between the dead plate and tines shall be checked as applicable.

14.14 Gates

(a) Leakage test shall be performed by the Contractor after installation of all Gates.

(b) Under the design seating head and unseating head the leakage shall not exceed the limit specified in IS:13349, for shop testing.

14.15 Reinforced Cement Concrete Pipes

(a) After laying and jointing of RCC pipes is completed the pipe line shall be washing out with sufficient water and be tested at work site as per the Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be

contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

(b) After the joints have thoroughly set and have been checked by the Engineer and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour.

(c) The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 liter/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

(d) In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

14.16 Steel Cylinder Pipes and Specials

(a) After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be washing out with sufficient water and be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.

(b) Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be re-welded. Any cracked or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Engineer.

(c) Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

(d) Where directed by the Engineer welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

(e) A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

(f) If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and re-welded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

(g) The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

14.17 Cast Iron, Ductile Iron Pipes and Fittings

(a) After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test after washing the pipe line out with sufficient water.

Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until at least two days have elapsed.

(b) Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge shall be applied by means of a pump connected to the pipe as directed by the Engineer.

(c) The duration of test shall not be less than 5 minutes. The exposed joints hall be carefully examined and all such joints showing visible leaks shall be re-caulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Engineer and the test shall be repeated to the satisfaction of the Engineer.

(d) After the satisfactory completion of pressure test, the section of pipe line shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm^3 /h as determined by the formula:

$$q_L = \frac{N D \sqrt{P}}{3.3}$$

Where,

q_L = The allowable leakage in cm^3/hr
N = Number of joints in the length of the pipeline
D = Diameter in mm, and
P = The average test pressure during the leakage test in Kg/cm^2

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to the Engineer until the leakage is within the specified allowance.

(e) Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

(f) After the tests mentioned above are completed to the satisfaction of the Engineer, the backfilling of trenches shall be done as per the Employer's Requirements specified elsewhere.

14.18 Manufacturer's Works Acceptance Tests on Electrical Equipment

The following equipment / items shall be subjected to inspection, routine /acceptance tests as per latest edition of relevant Indian / International standards in the presence of Employer/ his Engineer.

(a) 11/3.3 kV Transformers
(b) 11/0.433 kV Transformers
(c) 11 kV Metal enclosed switchboards & Switchgears.
(d) 3.3 kV Metal enclosed switchboards
(e) 415 V metal enclosed switchgears (PCC) /MCC
(f) Power capacitor and control panel
(g) Diesel Standby Generator with AMF Control Panel
(h) Battery, battery charger and DC Distribution Board
(i) Variable Frequency Drives
(j) Non Segregated Bus Duct
(k) Power & control cables
(l) Cable carrier system
(m) Lighting system
(n) Earthing and lightning protection systems

Copies of test Certificates for the type tests and Special tests not later than 5 years conducted as per relevant Indian / International Standards for all the equipment /items of above shall be furnished for the perusal of Employer / his Engineer. If type tests and special tests have not been conducted on any of these items, the same shall be carried out in the presence of owner/ Engineer at no extra cost.

14.19 Manufacturer's Works Acceptance Tests on Instrumentation, PLC, SCADA and Associated Equipment

A. Instrumentation:
Inspection, Testing and Setting to Work:
General

Each item of plant shall be subjected to the manufacturer's own tests which shall be certified.

Each item of plant and its installation shall be subject to inspection and testing at the place of manufacture.

The Contractor shall be responsible for the provision of all necessary test equipment. The Contractor shall demonstrate to the Engineer, the correct operation of any item of plant and the Engineer may witness any test. Tests which, in the opinion of the Engineer, were failed or not performed correctly shall be repeated.

Calibration tests for field instruments and analytical instruments should be conducted on site after installation and the same should be witnessed by the Engineer.

Before any test is made, the Contractor shall submit to the Engineer a full list of test equipment & test procedures (method statements) to be used. Each item of test equipment shall have a standard of accuracy better than that stated by the manufacturer of the item to be tested. The Contractor shall provide evidence of the condition and performance of any item of test equipment, in the form of test certificates issued by an appropriate authority independent of the Contractor and manufacturer, or as otherwise directed by the Engineer. Test equipment shall be checked frequently during the period of the tests.

The Contractor's staff responsible for supervising and carrying out tests shall be fully conversant with the various items of equipment of other manufacturers and if necessary the Contractor shall arrange for his personnel to attend suitable training courses on his own expense.

Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Engineer before proceeding with further inspection or testing of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

Preliminary Inspection and Testing at the Place of Manufacture

Field-mounted instruments

After the successful completion of the manufacturer's own inspection and testing of instruments supplied under the Contract, similar tests shall be carried out in the presence of the Engineer and the Contractor. Such tests shall include a demonstration that an increase or decrease of the measured value at several points over the full range of the instrument produces a corresponding increase or decrease in the instrument output signal. These tests shall include checks on the specified accuracy of the instrument at all points.

Instrument panels, enclosures and mounting boards

The manufacturer shall not present instrument panels, enclosures and mounting boards (assemblies) for inspection and testing until the manufacturer's own tests and inspection has been completed. A

preliminary inspection and test of these assemblies may then be witnessed by the Engineer. The Contractor shall give not less than 7 days' Prior notice in writing that he has completed.

His tests and inspection and is ready for the witnessed tests and inspection. Where this notice period is different in the Conditions of Contract this shall take precedent.
The witnessed inspection and testing shall include the following:

a. A visual inspection of the panel assembly to show that the design, construction and finish are satisfactory and in accordance with the Specification;
b. A check that equipment is securely mounted, accessible for removal or calibration without damage to or undue disturbance of other components, wiring or piping;
c. That all engraving and labels are correctly positioned, fixed and designated in accordance with the Specification;
d. Panel power-distribution circuits have the correct breaker/fuse rating coordination and designation;
e. Power-isolation facilities meet the Specification;
f. The main incoming supply voltage, frequency and/or pneumatic supply pressure is within the required limits, these being checked at the beginning and end of the test and the results recorded on test certificates;
g. The output of all power supply units again at the beginning and end of the testing with results being recorded;
h. The power supply voltage or air pressure of all component instruments of the assembly(s), these voltages/pressures being recorded on the test certificate;
i. The insulation resistance of all circuits except sensitive electronic equipment which is liable to damage by application of the test voltage, such circuits being disconnected before making the insulation resistance tests and these tests being carried out in accordance with IEE Wiring Regulations;
j. That the clean earth bar is isolated from main frame of the panel.

Internal lighting and anti-condensation heaters and associated thermostats, isolators, limit switches and wiring shall be checked for compliance with the Specification.

Spare capacity within the panel(s) shall be checked to see that it complies with the Specification. This shall include future equipment space, spare terminals, space in wiring trunkings and provision for additional cable entry.

Functional Testing at the Place of Manufacture

General requirements

Once the preliminary inspection and testing is complete to the satisfaction of the Engineer, functional testing shall commence. The purpose of the functional tests is to demonstrate that instrument panels enclosures and mounting boards (assemblies) conform to requirements of the Specification.

Not less than 30 days before the commencement of functional tests, the Contractor shall submit to the Engineer, for approval, two copies of comprehensive test procedural documents detailing each test to be carried out. The document shall include results forms on which the results of each test will be entered. The forms shall include spaces for numerical values, where necessary, and witness signatures.

All applicable drawings and data shall be provided at the place of inspection by the Contractor.

The Contractor shall provide all test instruments and equipment necessary to test the assemblies in their entirety.

The following is a typical list of the equipment required:

- Switch boxes;
- Indicator light boxes;
- Analogue signal sources;
- Dummy loads;
- Meters;
- Simulators;
- Desk-top computers;
- Programmers for DCS or outstations;
- Insulation test equipment

B. Programmable Logic Controller (PLC) and SCADA

The Contractor shall carry out specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled control panel containing the PLC and associated equipment in order to demonstrate correct functional operation of the hardware and software systems.

Factory Acceptance Test (FAT)

The Contractor shall conduct a full programme of tests of the PLC & SCADA system at the Contractor's testing facility in the presence of the Engineer to verify that all features of the system have been provided, are operating correctly and are in full compliance with the Specification. FAT shall include PLC based SCADA system for STP and PLC based control system with panel mounted HMI for SPS(s) with wireless communication system for the all of the above. Unless otherwise specified or agreed by the Engineer, the entire PLC & SCADA system shall be assembled and tested together as an integrated system, including all master station equipment, all operators' consoles, all outstations and telemetry equipment all instrumentation panels and uninterruptible power supplies included in this Specification. The scheduled date for the factory acceptance test shall be as agreed by the Contractor and the Engineer at least four weeks before the test.FAT shall be conducted with a hardwired simulation panel connected to the PLC based SCADA system. Contractor shall note the importance of the requirement. No software based simulation testing shall be accepted or allowed.

Not less than one month before the scheduled factory acceptance test, the Contractor shall submit to the Engineer for approval two copies of a comprehensive manual detailing each test to be conducted. The manual shall include a results form on which the results of each test will be entered, including spaces for numerical values where appropriate and witness signatures.

Not less than 7 days before the scheduled factory acceptance test, the Contractor shall give written notification to the Engineer that a complete dry-run of the factory acceptance test has been performed successfully and that, in the opinion of the Contractor, the system exhibits stable operation and is ready for the formal factory acceptance test.

The factory acceptance test will be considered successfully completed only when the system has successfully passed all factory tests. The system shall not be delivered to Site until the successful completion of the factory acceptance test is certified by the Engineer or unless otherwise approved by the Engineer. Delay in the delivery of the system due to failure of the factory acceptance test shall not constitute an unavoidable delay. If the system fails the factory acceptance test, the test shall be extended or rescheduled at the discretion of the Engineer.

All hardware to be used in the testing of the system shall have passed an agreed preliminary hardware performance test to ensure known hardware operability before software testing begins.

After successful completion of the factory acceptance test, no software changes shall be made to the system without written authorisation by the Engineer. Any changes to the system which effect the system software documentation, such as input scale modifications or changes to the control logic,

shall be entered into the system documentation before delivery of the system to Site. All instruments under IC&A scope has to be tested 100%.

Factory Acceptance Test Procedures

General

The scope of the tests shall include the proving of every aspect of hardware and software operation and functions as detailed below.

Hardware tests

(a) Verify the correct inventory of hardware including cables and printed circuit boards;
(b) Demonstrate that all spare-memory, disk-capacity and system-expansion requirements have been met;
(c) Demonstrate all hardware and software diagnostics;
(d) Verify all power supply voltages are within tolerance;
(e) Verify proper earth connections and isolation of instrumentation earth for all equipment;
(f) Demonstrate operation of test simulation and indication equipment and its Suitability for adequate functional testing of all system functions.

Software tests
(a) Demonstrate the editing of all system parameters including set-points, timers and the like;
(b) Demonstrate system configuration capabilities including the addition and deletion of input and output points, outstations, and all data base parameters;
(c) Demonstrate the addition, deletion and modification of mimic displays and report formats;

Functional tests

The functional tests shall verify proper operation of every specified system function as an integrated system. These tests shall be conducted in conjunction with functional tests of instrumentation and control panels as specified elsewhere. All failures or discrepancies found shall be documented in the test manual.

Following a failure of any functional test, should software or hardware modifications be required it shall be the decision of the Engineer whether the factory acceptance test is to continue, re-start or be aborted. If testing is allowed to continue, any changes which are required shall be described in a system modification document, signed by both Contractor and Engineer and be incorporated into the final factory acceptance test documentation. The failed test shall be re-conducted and the Engineer may require the retest of functions which may be affected by the modification.

The functional tests shall include, as a minimum, the following:

(a) Demonstration that the system meets the requirements of the Specification for response time and speed of screen update;
(b) Verification of the accuracy of all analogue input points in the system. The procedure shall include applying the appropriate signal to each analogue input at a minimum of three points within the range of the input, checking for expected numerical results, and verifying appropriate update of related mimic displays. Proper sensing and action by the system to high and low out-of-range inputs shall also be verified;
(c) Verification of the proper logic sense, pulse accumulation and rate computation where appropriate, of all digital inputs and verifying appropriate update of related mimic displays;
(e) Verification of all control and sequencing operations and proper operation of all digital and analogue outputs. The procedure shall include simulation of all related process variables for both normal and abnormal conditions, including instrument and component failure, and demonstration of fail-safe response of the system. System outputs shall be indicated with appropriate lamps and indicators;

(f) Simulation of outstation communications errors and failures and demonstration of error detection and handling, failure detection and handling, and appropriate changes to control actions as designed and specified;
(g) Verification of fault detection and diagnostics by inducing a sufficient variety of fault conditions in the system to ensure that detection processes and fail-safe operation are adequately tested;
(h) Demonstration of proper operation of all mimic displays, help pages, reports, operator procedures and historical data accumulation;
(j) Demonstration of proper operation of all outstations following a simulated master station central processor failure;
(k) Demonstration of proper operation of all equipment during both a system wide or isolated power failure, and following power restoration. The procedure shall include the demonstration of battery backup of both master station and outstation for the full length of time specified, and proper operation of power fail, low voltage warning and all associated alarms.

Reliability test

After successful completion of the functional tests a 48-hour continuous run of the system shall be performed. The test shall be passed if no system function is lost or no hardware or software failure occurs. Hardware failure is defined for this test as the loss of a major component such as the computer, an outstation, a VDU or a peripheral device. Non-repetitive mechanical failures of loggers, push-buttons and the like are excluded.

During this test, the system shall be exercised with simulated inputs and conditions in a manner which approximates the on-site operational environment. Unstructured testing by the Engineer shall be included during this test. Upon any system failure during this period, it shall be the decision of the Engineer whether the reliability test is to continue or be aborted. If testing is allowed to continue any changes to the system which are required shall be described in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final factory acceptance test documentation.

Factory acceptance test documentation

As a minimum, the following information shall be included in the factory Acceptance test manual for each test:

- Test identification number;
- Test name and description;
- List of all equipment to be tested including any special test equipment required;
- Description of the test procedure broken down into logical steps;
- Description of the expected system response verifying the completion of each logical step;
- Space for recording the results of the test and the time and date of the test;
- Space for signatures of the Contractor and the Engineer.

In addition, the Contractor shall provide a method for recording and tracing all problems, discrepancies, queries and suggestions regarding the system and software, and for formalised control of any modifications to the system.

Pre-commissioning tests

The Contractor shall perform pre-commissioning, or preliminary, testing of the SCADA system in accordance with that specified for instrumentation. The purpose of pre-commissioning tests is to confirm readiness of the system for commissioning.

The scope of pre-commissioning tests shall be generally as specified for factory acceptance tests but real field inputs and final control elements shall be used wherever practical to provide inputs to the system and to confirm proper outputs.

Where this is impractical, simulation signals shall be injected as near as possible to their ultimate sources so as to include in the tests as much of the cabling system as possible.
Each process system shall be set to work under manual control and the system tested to confirm proper operation. After proper operation of manual control mode has to be verified, tests of automatic controls of each process system shall be conducted wherever practical.

Commissioning

Site Acceptance Tests (SAT)

The Contractor shall submit all relevant draft operating manuals for the PLC & SCADA System to the Engineer for approval prior to commissioning tests.

Any faults or failures of the system detected during the previous tests shall be noted and corrected to the satisfaction of the Engineer before commissioning is allowed to commence.

As part of commissioning, the PLC & SCADA system shall be tested for availability for a continuous period of 60 days. During this period, the system will perform the normal functions according to the procedures described in the SAT documentation approved by the Engineer.

The system shall have passed the SAT if all major components have been free from fault or failure and exhibit full error-free functionality for 100 % of the total duration of the test, unless otherwise agreed by the Engineer. Major components include all master station equipment, outstations, communications facilities and instrument panel components, excluding push-buttons, switches and lamps and any equipment not supplied by the Contractor.

During SAT, no modifications to the system shall be made by the Contractor without the written approval of the Engineer. Erroneous functioning which requires software modifications or re-configuration to correct, other than set-point or parameter changes, shall constitute a failure of the availability test. Any changes to the system which are required and approved shall be described in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final test documentation. The test shall be restarted after corrections have been made.

14.20 Manufacturer's Works Acceptance Tests on Uninterruptible Power Supplies

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following:

(1) Change-over from full load with mains present to full load on battery supply
(2) Carry out a discharge test on the system at full load and for the specified duty bridging time period.
(3) Carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.

14.21 Inspection at Site

During erection of the Plant the Engineer will inspect the installation from time to time in the presence of the Contractor's Supervisor to establish conformity with the requirements of the Specification. Any deviations found shall be corrected as instructed by the Engineer.

14.22 Plant protection on Site

Factory finished plant shall be adequately protected both before and during installation against damage to finished surfaces, fitted components, and the ingress of dust. It may be necessary for structural finishing operations to be carried out in the vicinity of installed plant before it is taken over and the Contractor shall take this into consideration in complying with the requirement of this clause.

14.23 Erection staff

The Contractor shall provide at least two approved senior English speaking working erectors to supervise the erection of all Plant in the Contract and in each case to act as the Contractor's Representative as set out in Clause 13 of the general conditions of contract.

In the case of a foreign firm based overseas the Contractor's Representative shall be thoroughly conversant with the manufacturer's Plant and equipment, and its erection and shall be an expatriate.

The Contractor shall also provide sufficient erectors skilled in electrical, mechanical and instrument engineering, with such skilled, semi-skilled and unskilled labor as are necessary to ensure completion of the various sections of the Contract in the time required. The Contractor shall not remove any supervisory staff or labor from the site without the prior approval of the Engineer.

The Engineer will give the Contractor at least one month's notice in writing of the date on which the erection staff will be required on site, and the Contractor shall confirm the date of arrival in writing to the Engineer. The Contractor shall make all the necessary arrangements to ensure that sufficient plant has been or is about to be delivered to site, so that there shall be no delay to the start of erection.

It shall be the responsibility of the contractor to obtain necessary License / Authorization n/Permit for work from the Licensing Boards of the Locality/State where the work is to be carried out. The persons deputed by the Contractor's firm should also hold valid permits issued or recognized by the Licensing Board of the Locality/State where the work is to be carried out.

14.24 Erection and Building-in

The installation work shall comply with the latest applicable Standards, Regulations, Electricity Rules and Safety Codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

It will be the Contractor's responsibility to obtain approval/clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work or for installation carried out which comes under the purview of such authorities.

The Contractor shall carry out the complete erection of all plant, including the provision of all necessary skilled and unskilled labor, material, transportation, supplies, power and fuel, Contractor's Equipment and appurtenances necessary, for the complete and satisfactory erection of the Plant.

The Contractor shall have a separate cleaning gang to clean all equipment under erection and as well as the work area and the project site at regular intervals to the satisfaction of the employer. In case the cleaning is not up to the employer's satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the employer in this regard will be to the Contractor's account.

Erectors

The Contractor's employees shall include skilled erection staff in sufficient number, who shall arrive on the site on or before the respective dates set out in the approved work programmed and prior to

delivery of any item of Plant to the Site. The Engineer will not entertain any claim by the Contractor in respect of delayed erection due to a delay in the delivery of any items of Plant to the site.

Contractor's Equipment, materials and appurtenances

The Contractor shall have available on the Site sufficient suitable equipment and machinery, as well as all other materials and appurtenances required by him, of ample capacity to ensure the proper erection of Plant and to handle any emergencies such as may normally be expected in work of this character.

The Contractor shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment/component parts, after takeover by the Contractor, till the installation is taken over by Employer shall be made good by the Contractor to the satisfaction of Engineer.

Workmanship

Plant shall be erected in a neat and workmanlike manner on the foundation and at the locations and elevations shown on the approved drawings and other Engineering documents. Unless otherwise directed by the Engineer the Contractor shall adhere strictly to the aforesaid drawings and no departures there from will be permitted.
All plant shall be correctly aligned, leveled and adjusted for satisfactory operation and shall be installed so that the proper and satisfactory connection can be made readily between the various units and pipe work and equipment installed under the Contract. The mounting arrangements for pumpsets and blowers shall be such that the alignment offset between motors and the driven equipment shall be well within 0.1 mm.

Building-in

Erection of Plant shall be phased in such a manner so as not to obstruct the work being done by other contractors. Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of plant are to be installed, and shall bring any deviations from the required positions, lined or dimensions to the notice of the Engineer and shall take such measures as are necessary for their correction.

The Contractor shall take particular care for the correct positioning and alignment of all puddle pipes which are required through concrete structures prior to, and during the pouring of concrete.

The Contractor shall pin and plug in the holes prepared, all small clips, plugs, screws, nails, sleeves, inserts, etc., required for fixing electric wires and conduits, small pipe work and all other apparatus.

The Contractor shall align all equipment and holding down bolts and shall inform the Engineer before proceeding with grouting-in the item or item concerned. The Contractor shall ensure that all equipment is securely held and remain in correct alignment before, during and after grouting-in.

The Contractor shall properly bed in cement grout each item of plant or its supporting base resting on foundations, and shall grout-in where required holding down bolts placed in the holes prepared in the foundations. The materials and workmanship used in grouting shall be such as will result in a solid anchoring of foundation bolts and complete filling of the gaps between the Plant or its base and the foundations, without shrinkage or cracking.

During erection of the Plant the Employer will inspect the installation from time to time in the presence of the Contractor's Site representative to establish conformity with the requirements of the Specification. Any deviations and deficiencies found or evidence of unsatisfactory workmanship shall be corrected as instructed by the Employer.

All plant shall be installed in accordance with the recommendations or instructions of the manufacturer, for the particular application. Each mounting position shall be chosen to give correct operation of the equipment, ease of operation, access for maintenance and servicing and freedom from any condition which could have adverse affects.

Precautions

The approval by the Engineer of the Contractor's proposals for rigging and hoisting of any item of plant into its final position shall not relieve the Contractor from his responsibility for avoiding damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair or replace any damaged or injured items whether structural, mechanical, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Engineer.

No plant or other loads shall be moved across the floors of structures without first covering the floors with timber of sufficient size so that applied loads will be transferred to floor beams and girders of steel or concrete. If it is required to reduce bending stresses or deflection, the beam and girders shall be provided with temporary supports. Any movement of Plant and other loads over the floor structures shall be subject to the prior approval of the Engineer.

14.25 Civil Inspection (Water Leakage Test)

14.25.1 Tanks and basins

Refer to Part 10B – Particular Civil and Structural Works Requirements of the Bid Document

14.25.2

Field Control Inspection

Contractor shall be conduct periodic field control inspection to prevent any field accident. The Engineer shall joint field inspect or conduct unannounced inspections.

14.25.3 Inspection after Erection

After the erection of any item of Plant and its associated equipment has been completed, it shall beoffered to the Engineer for inspection in its static state prior to commissioning the item.

Completion of erection and procedure prior to setting to work.

The mechanical completion of plant under erection shall be deemed to occur if all the units/systems of the Works are structurally and mechanically complete as noted below:

All rotary, static, structural equipment, piping, electrical/instrumentation and other equipment under the scope of the Contract have been erected, installed and grouted and are as per the specifications. All systems have been washed/flushed/drained/boxed up where necessary.

All system testing including pressure, vacuum and nondestructive tests, no load tests and such other tests are completed with safety valves/relief valves set to operating conditions installed in position.

All panels, local control desks erected with power/control cable terminations with all continuity checks, insulation checks and other installation checks are carried out.

Prior to pre-commissioning checks, the Contractor shall erect the entire Plant and ensure readiness of civil works to the satisfaction of Employer, so that the Works are physically ready to undergo pre-commissioning checks. Pre-commissioning checks will include checks like no-load running of machinery, checks on instruments and electrical including calibration and loop checks, functional checks, inter-lock checks etc.

At the stage of mechanical completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete and the Plant is fit and sound to undergo pre-commissioning checks.

The following documentation shall be completed before the Contractor notifies Mechanical Completion of Erection to the Employer

(a) All shop inspection records compiled and bound in 4 (four) copies.
(b) All erection and commissioning procedures duly approved.
(c) All instruction manuals in draft form - with each sheet bearing a stamp to indicate "DRAFT FOR REVIEW ONLY" submitted in 4 (four) copies.

Upon achieving mechanical completion, the Contractor shall notify the Employer of such completion of section/units/systems and readiness for inspection for acceptance of mechanical completion of erection. The Employer/ Engineer shall proceed with inspection of such sections/units/systems within 10 days of such notice.

Consequent to inspection, the Employer will inform the Contractor a list of deficiencies for rectification and the Contractor shall complete the rectification work within a jointly agreed period prior to start of pre- commissioning tests. The erection period allowed by the Contractor shall include all activities of mechanical completion as noted above.

14.26 Site Acceptance Test Document

Fifty six (56) days prior to commencement of Tests on Completion the Contractor shall supply a Site Acceptance Test (SAT) Document for approval. This shall comprise four copies of the details of the inspection and test procedures to be carried out in testing the Works.

The SAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The SAT shall provide space within the documentation for results of the tests to be added and for each test and for the SAT as a whole to be signed off by the Contractor and the Engineer.

The SAT shall categories tests as follows:

a) Dry tests
   Dry tests are those tests carried out without process fluid being present.
b) Wet tests which can be further sub-divided into
   (1) Hydraulic tests
   Hydraulic wet tests are those tests carried out with potable water in order to prove the hydraulic capability of the Works.
   (2) Process tests /System tests
   Process wet tests are those tests carried out with raw Sewage as the feed stock to prove the process capability of the Works.

The Contractor shall make his own arrangements for water supply, chemical, electric power, fuel, instrument and labour during hydraulic wet tests.

It shall be assumed that the co-operation of other contractors in the carrying out of Tests on Completion will not be unreasonably withheld.

14.27 Tests on Completion

14.27.1 General

Prior to the commencement of Tests on Completion the Contractor shall submit for approval the following:

(1) Site Acceptance Test Documents
(2) As-Built Drawings
(3) Operation and Maintenance Manuals
(4) Site test results / data sheet and photo

Tests on Completion shall not be commenced until the aforementioned documents are approved.

The initial charges of oil, grease, electrolyte, generator fuel / oil, chemical, disposal of cake, etc. necessary for Tests on Completion shall be provided by the Contractor. Raw Sewage and electricity required for Tests on Completion will be provided by the Employer free of charge. If necessary, Contractor shall create design loading conditions for testing purposes by testing fewer than the total number of installed units of process tanks or equipment at a time. In such cases, multiple tests shall be conducted to ensure that all installed units are tested. In the event that raw sewage/influent wastewater is not available at the plant, the Contractor shall defer testing until such time as sewage becomes

available for treatment as described elsewhere in these Bid Documents. The Contractor shall provide adequate notice (this notice period shall be determined by the normal lead time for locally purchased chemicals plus at least 28 days) of his chemical requirements prior to commencement of the Tests on Completion involving their use.

The cost of chemicals used for the Tests on Completion shall be met by the Contractor.

The inspection and tests procedure which will be carried out are provided under the general conditions of contract and shall also consist of the following:

a) Manual Commissioning Tests (Clause i)

Manual Commissioning Tests shall be such preliminary trials, tests and retests on individual items of Plant or complete systems as are required by the Engineer in order to demonstrate that the Plant as a whole is ready to undergo the Manual Operation Tests (Clause 3.11) and that these will take place with a minimum of interruption.

The Manual Commissioning Tests shall demonstrate not only the items of Plant under normal operation, but also their response to abnormal and emergency conditions.

The Engineer will notify to the Contractor which items of Plant will be tested and the extent to which they will be tested in order to fulfill the requirements of the Specification.

Leakage tests at 1.5 maximum working pressure shall be carried out on all erected pipe work prior to the Manual Commissioning Tests.

Pump curves shall be available for the Manual Commissioning Tests and all instruments essential for the tests shall have been calibrated.

b) Manual Operation Tests (Clause ii)

When the Manual Commissioning Tests have been completed so that the items of Plant have been demonstrated to the satisfaction of the Employer Representative, the Contractor shall commence the Manual Operation Tests.

These tests shall demonstrate the correct operation of the whole Plant whilst using the minimum quantity of automatic control and monitoring equipment. Such equipment shall be at least that required both for the maintenance of safety and for the normal mode of operation of the Plant.

The Plant will be required to demonstrate satisfactory operation at all design flow rates.

The tests shall be of seven consecutive days' duration; if the supply of water should fail or other matters interfere outside the Contractor's control, the tests may be of such number of broken days as the Engineer considers is the equivalent.

The exact date of commencement shall be subject to the approval of the Engineer and shall be dependent on the following conditions having been met

(1) All relevant items of Plant in approved working order
(2) All items of Plant correctly identified with labels

c) Automatic Commissioning Tests (Clause iii)

The Automatic Commissioning Tests shall be such preliminary trials, tests and retests on individual items of Plant or complete system as are required by the Engineer in order to demonstrate that the Plant as a whole is ready to undergo the Tests of Completion (Clause 3.13) and that these will take place with a minimum of interruption.

At least one week before the commencement of these tests, the Engineer will notify the Contractor which items of Plant will be tested and the extent to which they will be tested in order to fulfill the requirements of the specification.

The Tests on Completion (Clause 3.13) as provided under the general conditions of contract-clause 37 shall not be carried out until the completion of the above tests.

(1) All pipe work shall be hydrostatically tested at site to a pressure equal to 1.5 times the maximum working pressure likely to be encountered in the system.
(2) The Contractor shall carry out all tests on the Plant and shall supply four copies of all test results to the Engineer.
(3) All tests shall be to the approval of the Engineer who may require them to be repeated, prolonged or modified as may be necessary to ensure that any or all items of Plant conform to the Contract.
(4) The Engineer shall be permitted to inspect all Plant which is undergoing tests and may himself conduct tests.

Where it is necessary for the Engineer to make arrangements for the supply of water, chemicals, power, etc., for any testing, the Contractor shall not commence the tests until after these arrangements have been made on or after a date agreed by the Engineer and the Contractor shall make no claim for delay to such testing on this account except as provided for under Clauses 44 of the General Conditions of contract.

If any item of plant fails during or after testing to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and re-tested and re-inspected as required by the Engineer.

Vibration/noise level tests shall be carried out at site which will form basis for acceptance of the equipment. If the Contractor is not in a position to meet the requirements given below as per ISO 10816 – 1995, the equipment may either be rejected or the Contractor shall carry out all necessary modifications to keep vibrations within the acceptable limits specified.

Equipment	Noise Level (dBA at 1.86 m from equipment)	Velocity of vibration (mm/sec)
All rotating equipment not having reciprocating parts with motor kW less than or equal to 15 kW	85	1.12
All rotating equipment not having reciprocating parts with motor kW more than 15 kW and less than or equal to 75 kW	85	1.8
All rotating equipment not having reciprocating parts with motor kW greater than 75 kW	85	2.8
All equipment having reciprocating parts viz. compressors, dosing pumps sampling pumps	85	-

The Contractor shall have a minimum of three commissioning engineers, one for process and plant and the other for mechanical/electrical/instrumentation works on site during all tests in order to both demonstrate the Plant and to correct any faults which may occur.

14.28 Dry Test Requirements

As a minimum requirement the following dry tests shall be carried out as a general requirement:

(1) A general inspection to check for correct assembly and quality of workmanship
(2) A check on the presence of lubricant, cooling medium, electrolyte, etc.
(3) A check on adequacy and security of Plant fixing arrangements.
(4) A general check to ensure that all covers, access ladders, water proofing, guard railings etc are in place.
(5) A check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of apertures between building structures, chambers etc and the outside.

a) Civil and Building Works

As a minimum requirement the following dry tests shall be carried out on the civil engineering and building works:
- Check for the presence of foreign bodies in pipe work and structures.

b) Mechanical Works

As a minimum requirement the following dry tests shall be carried out on the mechanical systems:
- Carry out preliminary running checks as far is permitted by circumstances in order to ensure smooth operation of Plant.

c) Electrical Works

As a minimum requirement the following dry tests shall be carried out on the electrical systems:
(1) Check phasing and polarity.
(2) Carry out point to point check on all cables.
(3) Check on security of cable terminations.
(4) Check on completeness and adequacy of earthing systems.
(5) Check setting on protection relays, sizes of fuses and motor overload settings.
(6) Carry out checks on cabling systems in accordance with the requirements of the relevant standards.
(7) Check operation of main circuit breakers by secondary injection methods.
(8) Check rotational direction of Plant.
(9) Check instrument loop integrity, functionality and calibration.
(10) Check operation of standby generator installation and mains / generator changeover procedures; a 4 hour load test (using the normal load of the Works) shall be carried out on the generator when the load is available.

(11) Check plant functionality.
(12) Check functionality of the central MMI and its power supply.

14.29 Process Plant Item / Equipment

All process plant items / equipment shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction and performance.

14.30 Hydraulic Wet Test Requirements

Hydraulic wet tests shall be carried out on completion of dry tests.

Clear Water shall be used for hydraulic wet tests. The purpose of the tests is to prove the hydraulic performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is hydraulically loaded to its rated throughput for a period of at least four hours.

In order to ensure a sufficient supply of water to carry out these tests the Contractor shall provide all required facilities, including but not limited to any temporary facilities that may be required for storage and recycle of Clear Water or facilities for the disposal of the water off Site in an approved manner.

The following tests inter alia shall be carried out:

(1) Pressure testing of all piped systems lay direct in ground in accordance with the relevant standards.
(2) Fill all structures and check for leaks.
(3) Filling of all storage vessels to check for leaks and distortion.
(4) Running of all pumped systems in order to check for.
i) Correct functionality.
ii) Absence of leaks.
iii) Correct running temperatures.
iv) Smoothness of running and the absence of undue vibration or stress.
v) Check drive running currents.
(5) Carry out calibration of instruments where appropriate.
(6) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
(7) Demonstrate correct functionality of electrical, control and instrumentation systems.

The Contractor shall simulate the conditions that will prevail when operating as a process in order to demonstrate the correct functionality of process control loops etc.

During these tests a check on the performance of Plant shall be made to compare its site performance with the factory test data and to identify any constraints on performance due to site conditions.

14.31 Safety Audit

After satisfactory completion of hydraulic wet tests and prior to introduction of process fluid to the plant a safety audit shall be carried out to ensure compliance with the necessary requirement for safety and for operation of Plant. The safety audit shall be documented. The safety audit document shall be approved by the Engineer prior to commencement of Plant commissioning.

14.32 Process Wet Tests (with Raw Sewage)

On approval by the Engineer the Contractor shall carry out process wet tests.

Raw Sewage shall be used as the main feed stock for process wet tests. These tests shall be carried out to demonstrate the process performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is loaded to its rated throughput (including a period of overload if

required in order to demonstrate compliance with the Employer's Requirements) for a continuous stable operating period of not less than 48 hours. If necessary, Contractor shall create design loading conditions for testing purposes by testing fewer than the total number of installed units of process tanks or equipment at a time. In such cases, multiple tests shall be conducted to ensure that all installed units are tested.

The Contractor shall provide all required facilities for the disposal off Site in an approved manner. The following tests inter alia shall be carried out:

(1) Check for leaks on vessels, structures, pumps and pipe work.
(2) Running of all pumped systems in order to check for.
- ✓ Correct functionality.
- ✓ Absence of leaks.
- ✓ Correct running temperatures.
- ✓ Smoothness of running and the absence of undue vibration or stress.
- ✓ Check drive running currents where the solution pumped is different from that pumped during hydraulic wet tests.

(3) Carry out calibration of instruments.
(4) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
(5) Demonstrate correct functionality of electrical, control and instrumentation systems not checked during dry or hydraulic wet tests or which may have changed as a result of the different operating conditions now prevailing.

On completion of the tests on the various parts of the works the Contractor shall run the plant as a whole in order to demonstrate the full functionality and performance of the Works at various throughput rates for a continuous period of not less than 30 days.

During the various process tests the Contractor shall perform sampling and analysis of all the process streams (locations) and parameters listed in the "Sampling/Analysis Locations and Frequencies" table provided in the "Tests after Completion" Section below. The frequencies listed in this table shall be followed for the Tests after Completion. However, for the Process Wet Tests performed as part of the Tests on Completion, the sampling frequency for all locations and all parameters shall not be less than once every hour. The Contractor shall demonstrate to the Engineer that the Works is functioning in accordance with the Employer"s Requirements. Each sample shall comprise two 1 litre (minimum) quantities and shall be labelled to identify the contents, where taken and time and date. The flow recorded at the time of sampling shall also be indicated in the log book or record. One sample shall be used by the Contractor for his analysis; the other shall be handed over to the Engineer.

The Engineer reserves the right to take additional samples and to carry out his own tests or to check the samples taken by the Contractor.

The Engineer shall be given reasonable access to the premises where analysis is taking place in order to check on working practices and the procedures being adopted.

14.33 Effluent Quality Criteria for Passing the Tests On Completion

The Works shall be considered to have achieved the required effluent quality standards for passing Tests on Completion if all samples taken during a 30 day continuous operational period comply with the criteria set down for passing the Tests after Completion. This includes criteria relating to the reliability of the plant.

The Effluent quality Tests on Completion shall not be commenced until all tests associated with the civil/building, electrical and mechanical works and individual process tests have been completed to the satisfaction of the Engineer.

14.34 Co-operation with other Contractors in the Execution of their Tests

The Contractor shall, where required, assist other contractors in carrying out their tests on completion and or tests after completion.

Where this assistance does not constitute part of the Contractors own work associated with Tests on Completion or Tests after Completion the Contractor shall be reimbursed at the rates approved by the Engineer.

14.35 Tests After Completion

General

On successful completion of "Test on Completion" the Contractor shall carry out over a period of time not exceeding six months two separate 30 days operational tests. These tests shall be used to prove the operation of the Works at varying flows and with varying raw Sewage quality. During these tests Effluent produced by the Works will be entering the disposal system. These tests after completion shall be undertaken in accordance with Clause 11 of the General Conditions of Contract.

The timing of the tests shall be determined by the Employer who shall give notice to the Contractor in accordance with Sub-clause 11.1 of the General Conditions of Contract. The total time for carryingout the tests shall not be less than six calendar months. One of the tests for each part shall be carried out in a period of high raw Sewage BOD and suspended solids.

On commencement of each 30-Days test the Employer shall allocate a continuous period of not greater than 60 days to complete the test. Any failure to perform during the 60 days period shall restart the "30 day clock'. If the part of the Works fails to pass the test in the 60 days period the test shall be deemed as a failure and the Contractor shall carry out any necessary remedial work to the satisfaction of the Engineer before the Contractor restarts the test.

During the tests the Contractor shall take samples to demonstrate that the part of the Works is performing in accordance with the Employer's Requirements. The procedure for taking the samples shall follow the pattern adopted for Test on Completion. Samples shall be taken at locations and intervals detailed below. The results of the Tests after Completion shall be compared and evaluated by the Employer and Contractor.

The Contractor will not be held responsible for interruptions to the sewage treatment process as a result of Grid power failures (unless as a result of a Plant failure) interruptions in the raw Sewage supply etc. which are out of his control. However, the Contractor shall be required to demonstrate that the Works can cope with these inevitable interruptions in an orderly fashion and recover to a normal operational state with the minimum of manual intervention.

All consumables except power needed for operation of the Works shall be provided by the Contractor.

The Contractor shall provide all facilities and equipment not supplied under the contract and which are deemed necessary for the Contractor to carry out and monitor the Tests after Completion.

Sampling and Analysis

Sampling and analysis shall be performed to measure the parameters indicated in the table below, at the locations and frequencies indicated in the table. In case of multiple units (such as multiple aeration basins or clarifiers), the indicated sampling and analyses shall be performed for each individual module.

Sampling/Analysis Locations and Frequencies

Sample Location and Parameters to be Measured	Frequency	Sampling Method
Plant Effluent (outlet of chlorine contact tank): All parameters specified under the "Effluent Quality Requirements" sub-section of Volume 2, Section 7, Part 5.	Daily	Flow-weighted 24-hour composite
Dewatered Sludge: All parameters specified under the "Dewatered Sludge Quality Requirements" sub-section of Volume 2, Section 7, Part 5.	Daily	Composite of samples from each container or vehicle filled during the day
Raw Sewage Influent, Plant Effluent, Primary Sludge, Dewatering Influent, Plant Recycles: Flow	Continuous	Continuous instantaneous flow from recorder
Raw Sewage Influent, Primary Effluent, and Secondary Effluent: TSS, VSS, Temperature, pH	Daily	Flow-weighted 24-hour composite
Raw Sewage Influent, Primary Effluent, and Secondary Effluent: BOD, COD, TKN, Ammonia-N, Nitrite-N, Nitrate-N, Alkalinity, Total Phosphorus, Soluble Phosphorus	3 times per week	Flow-weighted 24-hour composite
Aeration Basins: MLSS, MLVSS, Temperature, SVI	Daily	Grab
Aeration Basin Zone Profiles (Anaerobic, Anoxic, Aerobic): Ammonia-N, Nitrite-N, Nitrate-N, pH, Soluble Phosphorus, VFAs, RBCOD	3 times per week	Grab
Dewatered Sludge: TSS, VSS	Daily	Grab
Sludge Collection & Handling Zones; Sludge temperature, sludge concentration, sludge VSS destruction, sludge pH, alkalinity, VFA concentration, gas production volume, gas pressure, gas methane content, gas hydrogen sulphide content, gas humidity,	Daily	Grab
Chemicals/Scum/Screenings/Grit: Specific weight, volume, weight, Chemical consumption	3 times per week	Grab

All costs associated with the taking and analysis of samples shall be met by the Contractor.

The analysis shall be carried out by certified laboratory approved by the Engineer, and shall be performed in strict compliance with appropriate analytical methods published in Indian Standards, or in "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, or as published by the US Environmental Protection Agency. The Contractor shall submit to the Engineer a comprehensive report of the above sampling and analysis, including details of each analytical test as well as a summary of all the data and results in a Microsoft Excel spreadsheet.

Criteria for Passing the Test after Completion

(1) Treated Effluent and Dewatered Sludge Quality Criteria

The Works shall be deemed to have met the Treated Effluent and Dewatered Sludge Quality Criteria if:

(i) At least 95 percent of the plant effluent samples described above meet the requirements specified under the "Effluent Quality Requirements" sub-section of Volume 2, Section 7, Part 5, and

(ii) At least 95 percent of the dewatered sludge samples described above meet the requirements specified under the "Dewatered Sludge Quality Requirements" sub-section of Volume 2, Section 7, Part 5.

(2) Operational Cost Criteria

The plants shall have fulfilled the operating cost criteria if the operating costs determined during the Tests After Completion are in agreement with or less than those detailed in the Contractor‟s Functional Guarantee or an amount of liquidated damages are agreed by the Contractor and the Engineer to compensate for any short fall in performance up to an agreed maximum amount if stated.

(3) Plant Reliability Criteria

A part of the Works shall be deemed to have failed its test if:

(1) A single item of Plant / equipment fails more than twice during the test.
(2) More than four individual Plant items / equipment fail.
An item of Plant / equipment shall be deemed to have failed if manual intervention is required in order to restore the Plant / equipment to its fully operational state: i.e. the failure of a duty drive will be considered as one failure, if the standby drive fails to start that will be considered as a second failure.

14.36 Performance Certificate

The conditions for issuance of a Performance Certificate as detailed in Clause 12 of the Conditions of Contract shall inter alia comprise:

a) The completion of the six months operation of the Works (Tests after Completion) to the satisfaction of the Engineer.
b) The O & M Manuals have been updated following one year's operational experience and approved by the Engineer.
c) All defects identified prior to Taking Over and defects identified during one year operation of the Works have been rectified.
d) All Tests "After Completion" have been completed to the satisfaction of the Engineer.
e) All training detailed in the Employer's Requirements has been completed.

End of Part 14

PART 15

TRAINING REQUIREMENTS

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PART 15

TRAINING REQUIREMENTS

15.1 Training Requirements

15.2 General

The Contractor shall provide comprehensive training for the different categories of the Employers operation and maintenance staff. Training shall fall into two main types which are 'off the job' and 'on the job'. Off the job training shall take place in the class room and on the job training shall be carried out on the running plant(s).

15.3 Off The Job Training

The Contractor shall prepare formal training documentation for distribution to the trainees. Visual aids shall be used to illustrate the points being made and to make the training programme interesting and enjoyable for the participants.

The off the job training shall comprise the following:

1. Off the Job Training Programme for all Trainees

To provide training:

a) on the simple physical-chemical and biological process principles involved in the operation of the Works;
b) regarding basic features of the electro-mechanical and instrumentation equipment to be installed
c) health and safety;
d) plant safety procedures;
e) on the use of the local and central HMIs and SCADA.
f) Monitoring devices;
g) Operational performance index.

2. Off the Job Process Training Programme for Operators

To provide training:

a) on the operation of individual items of plant and sections of the Works including automatic operation and manual operation;
b) on the day to day operation of the Works and procedures;
c) on a comprehensive list of 'what if' scenarios dealing with the actions to be taken in the event of potential process problems, alarms, plant failures, overflows, power failures etc.;
d) on first line mechanical maintenance;
e) safe work practices;
f) on safety procedures to be followed in operating, maintaining, and cleaning the plant;
g) special procedures to be followed in the event of chlorine leak.
h) Creation of O/M forms;
i) Troubleshooting.

3. Off the Job Training Programme for Electrical Maintenance Staff

To provide training:

a) on the configuration, construction and operation of the electrical Plant;
b) on the electrical maintenance requirements of the Works;
c) on the switching and safety procedures to be followed;
d) safe methods of working;
e) on fault finding and repair procedures.
f) Creation of O/M forms;
g) Troubleshooting.

4. Off the Job Training Programme for Control and Instrumentation (ICA) Maintenance Staff (Refer clause no. 15.7)

5. Off the Job Training Programme for Mechanical Maintenance Staff

To provide training:

a) On the routine mechanical maintenance requirements of the Works;
b) On lubrication requirements of the Works;
c) On fault finding, repair and overhaul procedures;
d) Cleaning & maintenance method ;
e) Safe methods of working
h) Creation of O&M forms;
g) Troubleshooting.

6. Off the Job Training Programme for Sewage Treatment Management Staff

To provide training:

a) Sewage treatment process management techniques;
b) Sewage treatment plant cost management;
c) Sewage treatment plant laboratory management;
d) Safe methods of work general;
e) On safety procedures to be followed in operating, maintaining and cleaning the plant;
f) Creation of O&M management Index;
g) Creation of Asset/Property ledger and Management method;

7. Off the Job Training Programme for Sewage Pumping Station (SPS) Staff

To provide training:

a) Process management techniques;
b) Plant cost management;
c) Safe methods of work general;
d) On safety procedures to be followed in operating, maintaining and cleaning the plant
e) Cleaning & Maintenance method ;
f) Creation of O/M forms;
g) Troubleshooting.

15.4 On The Job Training

The Contractor shall utilise the Operation and Maintenance Manuals as the primary training aid in carrying out the on the job training. Shortcomings, omissions and errors identified in the O & M Manuals during the training shall be rectified prior to final acceptance of the O & M Manuals.

1. On the Job Training Programme for all Trainees

To provide training:

a) Plant familiarisation tour;
b) On the use of the local and central hmis/scada;
c) Health and safety;
d) Identify areas where special safety precautions are necessary.

2. On the Job Process Training Programme for Operators

To provide training:

a) under operational conditions on the operation of individual items of plant and sections of the Works including automatic operation and manual operation;
b) illustrate by example the day to day operation of the Works and procedures;
c) illustrate by example the actions to be taken in the event of potential process problems, alarms, plant failures overflows, power failures etc. (as identified in the 'what if' scenario off the job training);
d) illustrate by example the first line mechanical maintenance;
e) illustrate by example safety procedures to be followed in operation, maintenance and cleaning of the Works;
f) Operation at the time of change of inflow load;

g) Measure against sludge bulking at settling basins and Biological treatment basins;
h) Proper management method of a sludge treatment facilities;
i) Evaluation of Process Monitoring;
j) Water quality testing;
k) Entry and evaluation of everyday performance data ;
l) Creation of various types of a report of a day, monthly, and a fiscal year using PC.

3. On the Job Training Programme for Electrical Maintenance Staff
To provide training:
a) Carry out detail tour of the electrical plant;
b) Illustrate by example the operation of the electrical plant;
c) Illustrate by example the electrical isolation and maintenance procedures;
d) Illustrate by example fault finding and repair procedures;
e) Illustrate by example switching and safety procedures to be followed;
f) Illustrate by example safe systems of work;
g) Entry and evaluation of everyday performance data;
h) Creation of various types of a report of a day, the monthly, and a fiscal year.

4. On the Job Training Programme for Control and Instrumentation Maintenance Staff (Refer clause no. 15.7 below)

5. On the Job Training Programme for Mechanical Maintenance Staff
To provide training:
a) Illustrate by example the routine mechanical maintenance requirements of the Works;
b) Illustrate by example lubrication procedures;
c) Illustrate by example fault finding, repair and overhaul procedures.
d) Illustrate by example safe systems of work;
e) Entry and evaluation of everyday performance data;
f) Creation of various types of a report of a day, the monthly, and a fiscal year.

15.5 Training Programme

Off the job training shall be carried out prior to Taking Over of the Works or any section of the Works.
Off the Job training shall be carried out prior to On the Job training. On the Job training shall be completed as a condition for acceptance of the Works following completion of the Tests after Completion.

The Contractor shall provide a training plan for each category of staff. The training plan shall detail the content and duration of each course. The training plan shall be submitted for the approval of the Engineer at least 120 days prior to the commencement of the Tests on Completion. The duration of training offered for each category of staff shall not be less than that detailed in the following table.

Category of Staff	Off the Job (minimum days duration for each course)	On the Job (minimum days duration for each course)
All staff	1	1
Operator	3	5
Electrical technician/electrician	2	2
Control/instrument technician	10	5
Mechanical technician/fitter	2	2
PS/STP management	3	(see note)

Note: It is assumed that PS/STP managers on the job training will be continuous throughout 12 months in a calendar year when the plant(s) is operated by the Contractor.

The training day shall be assumed to be not less than 8 (eight) hours split into two sessions. The Contractor shall provide facilities for training which shall include inter alia the training rooms/locations, tables and chairs, projectors, white/black boards, training aids, training manuals etc.

Where trainees of a given category can all be released from their Works operational duties simultaneously they may be trained together. Where this is not possible the Contractor shall repeat the complete course for those who could not attend.

15.6 Training Personnel

The Contractor shall provide suitably qualified trainers to carry out the off the job and on the job training.

The trainers are to be experienced in sewage treatment plant and sewage pumping station management, operation and maintenance in their relevant discipline and in the training of skilled and unskilled staff.

The Contractor shall submit the curriculum vitae of the trainer nominee's to the Engineer for approval 120 days prior to the commencement of the Tests on Completion. The training expert shall be fluent in English, Hindi and Kannada Languages or the Contractor shall provide the services of an interpreter during the training periods.

15.7 Instrumentation, Control & Automation Training requirements

The Contractor/ system supplier shall conduct training courses for personnel selected by Bangalore Development Authority (BDA). Training shall be conducted by personnel employed by the Contractor/ system supplier familiar with the system supplied and who have experience and training in developing and implementing instructional courses.
The contractor shall arrange training for the Bangalore Development Authority (BDA) personnel for 5 days before the conduction of FAT. This training shall be separate from the training for Bangalore Development Authority (BDA) (2 sessions of 5 days each) which shall be conducted during SAT.

The entire cost of the complete training programme, including reasonable per diem expenses to cover meals, lodging, transport and similar expenses for all Bangalore Development Authority (BDA) personnel and the consultants attending the training program, shall be the responsibility of the Contractor/ system supplier and shall be included in the contract price.

The Contractor/ system supplier shall submit information on the training programme for approval, prior to shipment of the equipment. This submittal shall include a course outline; time required, course schedule, sample workbook and instructor qualification information for each level.

The Contractor/ system supplier shall make a workbook on each course available to every person taking the courses listed herein. The workbook shall be of sufficient detail so that, at a later date, a trainee could review in detail the major topics of the course.

The training times shall be scheduled by the Bangalore Development Authority (BDA) in advance with the Contractor/ system supplier so as not to disrupt the Bangalore Development Authority (BDA)'s ability to operate the plant.

Operations and Maintenance Training

Training shall be provided for ten (10) of the Bangalore Development Authority (BDA) personnel at the Contractor/ system supplier facility on operations and maintenance of all system components. The training program shall be divided into two segments and shall consist of at least 5 (five) working days, each of 8 (eight) hours duration.

The maintenance training program shall be developed for personnel that have electronics maintenance and repair experience and a general knowledge of computer systems, but shall not assume any familiarity with the specific hardware furnished.

As a minimum, the following subjects shall be covered:
System Architecture and Layout
Hardware Components
Module Switch Settings (Configuration Switches)
I/O Modules
Power Supplies
Data Highway:
Programmer connection
IOP programming and diagnostic techniques
Battery replacement and recharging
PC and workstation familiarization and maintenance:
Troubleshooting
Disassembly
Cleaning
Component Replacement
Re-assembly
The operation training programme shall include the following topics:
Power-up, bootstrapping and shutdown of all hardware devices
Interpretation of all standard displays
Appropriate actions for software and hardware error occurrences
Use of operator interface displays and keyboards
Use of printer including replenishment of supplies
Manual data entries
Creation and editing of graphic operator display screens.
Loading of any required software into the system
Data base creation and editing.

15.8 Training Assessment

At the conclusion of off-job and on-job training, all the trainees shall be asked to undergo a simple assessment / test to examine the level of understanding of the working of an STP and the effectiveness of the training program. The feedback gathered from the assessment / test shall be used by the Managers to make a decision whether some of the trainees need to be re-trained.

The managers who will be at continuous training for 12 month period will have to be assessed/ tested after completion of the 12 month period.

The contractor shall prepare the proposed assessment / testing questionnaire and submit for approval before commencement of the training program.

End of Part 15

PART 16

OPERATION AND MAINTENANCE
(TO BE DISCUSSED)

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PART 16

OPERATION AND MAINTENANCE

This section applies to the specifications of materials used for operation and maintenance, the workmanship, period for routine maintenance, specifications for the acceptable quality of plant effluent, maintenance of records, and responsibilities during operation and maintenance period. The Contractor shall provide access to the Site for the Engineers for the purpose of monitoring the Contractor's Operation and Maintenance activities. The Contractor shall train the Bangalore Development Authority (BDA) personnel who will operate the plants for the last year of the 03 (Three) years Operation and Maintenance period.

16.1 Operation and Maintenance Requirements

The Contractor shall operate and maintain all the works and plants of the Sewage Treatment Plant (STP) under the Contract complete including the road works, landscaping, civil/structural, mechanical components instrumentation system, Electrical System of STP, SCADA systems, all utility and ancillary buildings, STP premises area for the period of **Three (03) years** from the date of successful completion of "Tests after Completion of the Works".

The Contractor shall make his own arrangements at his own cost for plant operation personnel, chemicals usage, lubricants, diesel, spares, tools and tackles, routine maintenance, sampling and analysis, screenings and grit collection, transportation and disposal, dewatered sludge disposal/sale, co-ordination with BDA, Karnataka State Pollution Control Board (KSPCB), BESCO, LDA, KSEPA authorities and any other activity required for the operation and maintenance of the works / plants in full compliance with all applicable rules, regulations, laws, codes, effluent quality requirements and any other limitations.

The diesel hours to be considered in estimating the power breakdown period is as under:

Normally Shut down time shall be considered as Average 2 hrs. per day on Monthly basis. Contractor shall pay for diesel charges for running the STP for this period. Bangalore Development Authority (BDA) will pay for any additional consumption of diesel when power shutdown period exceed 60 hours per month.

The cost of electrical energy consumed for the operation of the Plant will be borne by Bangalore Development Authority (BDA) up to the amount corresponding to the guaranteed specific energy consumption specified by the Contractor in the Technical Schedule or as agreed between Bangalore Development Authority (BDA) and the Contractor. The Contractor shall bear additional electrical energy consumption charges above the amount indicated above.

During the Operation and Maintenance period, the Contractor shall collect, transport, and dispose of the screenings, grit, and dewatered sludge cake in full compliance with all applicable laws, rules, and regulations.

The Contractor shall submit a weekly report to the Employer detailing the Operation and Maintenance indicating the labour hours expended, Electrical Power Consumed, Chemicals and other Consumables consumed and also any problems including troubleshooting faced and rectified. The report shall also include full details including photos and complete results of all sampling and analysis conducted. The sampling locations, parameters analyzed, and sampling/analysis frequencies shall be as listed in the "Sampling/Analysis Locations and Frequencies" table in the "Sampling and Analysis" section of Volume 2, Section 7, Part 14 of these bid documents, at a minimum.

The Contractor shall submit detailed schedule/manual of all O&M activities and contents with references of equipment manufacturer's maintenance schedules/manuals to the employer for review and approval.

The Contractor shall carry out all O&M activities as per the approved Operation and Maintenance Manuals.

During the Operation and Maintenance period, the Contractor shall ensure that the stipulated design effluent standards are met in accordance with the specifications in the Bid documents.

The Contractor's responsibility shall also include the safety and security of the works / plants during the course of Operation and Maintenance.

During Operation and Maintenance period, the Contractor shall appoint a Plant In-Charge, Lead Operator and Laboratory Technician. In addition, the Contractor shall appoint suitable number of operators, fitters, electricians, helpers, gardeners, office peons, security guards, labourers as required for the operation and maintenance of the plants for three shifts and adequate other staff / supporting personnel during general shift.

Key O&M personnel shall have minimum qualification and experience as given below:

Minimum Staff and Qualifications Requirements during O&M Period

Sr. No.	Designation	Qualifications	Experience in Years	Total No. for each STP
1	Plant Manager	Graduate/ Post Graduate in Civil, Public Health or Environmental Engineering with specialization in wastewater collection and treatment and having experience in STP and Sewage Pumping Stations Testing, Commissioning, Operation & Maintenance, Liaison with Government, Pollution Control Authorities. Shall have completed at least one CPHEEO advanced Wastewater Operations course or equivalent.	10	1
2	Plant Supervisor/ Superintendent	Graduate in Civil, Public Health, or Environmental Engineering with specialization in wastewater collection and treatment. Shall have completed at least one CPHEEO advanced Wastewater Operations course or equivalent.	5	1
3	Shift-in-charge	Diploma in Civil, Public Health, or Environmental Engineering with specialization in wastewater collection and treatment. Shall have completed at least one CPHEEO advanced Wastewater Operations course or equivalent.	5	3 (Three Shifts, 1 for each shift)
4	Operators for STP Operators for Pump Stations	Diploma in Civil, Public Health, or Environmental Engineering with specialization in wastewater collection and treatment. Shall have completed at least one CPHEEO basic Wastewater Operations course or equivalent. Diploma in Mechanical/Electrical Engineering	3	• 15
5	Plant Chemist	Graduate in Environmental Science / Chemistry having experience in STP laboratory (sampling / analysis)/ operation and maintenance.	3	1
6	Electrician	Diploma/ ITI Certification in Electrical Engineering with experience in STP & SPS Erection, Testing, Commissioning, Operation & Maintenance.	3	1
7	Instrumentation	Diploma/ ITI Certification in	3	1

	and Control Technician	Instrumentation and Control Engineering with experience in STP & SPS Erection, Testing, Commissioning, Operation & Maintenance.		
8	Fitter/Mechanic	Diploma/ ITI Certification in Mechanical Engineering with experience in STP & SPS Erection, Testing, Commissioning, Operation & Maintenance.	3	3
9	Peon	10th Pass	2	1
10	A)Security Guards for STP	8th Pass	3	3
11	Gardener	8th Pass	1	2
12	Helpers for Sludge Handling	-	-	3

Note:

a. The above requirement is minimum only. The Contractor will arrange extra work force, as and when required, so as to smoothly run the operation and maintenance including preventive maintenance, repairs etc. and general cleanliness of the installations.

b. The above staff strength is exclusive of leave reserve required for different category of staff. The Contractor shall ensure availability of the personnel given in the above table for all seven days in a week.

c. The Contractor shall make appropriate arrangements for maintenance of items like road work, buildings, arboriculture, patrolling and maintenance of civil structures, vehicle operations and other activities defined to fulfill its obligations under O&M Contract.

The Contractor shall furnish complete resumes/biodata for all personnel proposed two months before the start of Operation and Maintenance period to the Engineer for approval.

16.2 Typical items in Pump stations & their checks

The purpose of maintenance is shown below.

- Pump up sewage to sewage treatment plant etc.
  Maintenance and management of facilities are divided into operation surveillance work and preservation work.
- Operation surveillance work is the surveillance of apparatus operation, apparatus operation at the time of usual, a pumping mode at the time of a heavy rain, and correspondence at the time of a power failure.
- -Preservation work is inspection check, a periodic check, apparatus maintenance, repair of failure apparatus, cleaning, etc.

The item of the main preservation work is shown below.

Name of Facility	**Daily**	**Periodic**	
	Point to be checked	Frequency	**Point to be checked**
Motorised Gates	-Check Smooth-Operation -Check safety equipment	Weekly	-Check Greases up & Oils -Smoothness of operation (Fully open & Close)
		Monthly	-Check opening-and-closing time
Wet well, Channels and Chamber	-Removal of floating matter -Check of a water level	As needed basis	-Cleaning of a sediment -Check H_2S gas concentration
Coarse & Fine screens	-Check Smooth-Operation -Check of the difference of the water level before and behind a screen -Remove un-removable floating matter on screens -Clean-up drop garbage -Clean-up Top of Screen -Check abnormal noise -Check safety equipment -Check manual cleaning equipment Correctness	Monthly	-Adjustment of take-up for Drive chain -Check Screen- shape -Check Operation of a wiper -Adjustment of space between rakes and a screen -Check of the lubricating oil level of reduction gears -Check Rake-speed -Check emergency stop system
Screening Conveyor	-Check Smooth-Operation-Abnormal noise -Meandering of a belt -Check scraper performance -Check rollers-performance -Cleaning of Conveyor -Check safety equipment	Weekly	-Grease up & Oils - belts
		Monthly	-Check Damage to a belt -Check Slack of a belt& adjustment of take-up -Check of an emergency shutdown system -Check Belt-speed
Submersible Pumps	-Check Smooth-Operation -Check discharge rate, pressure, abnormal noise, Vibration -Check up minimum submergence in wet well -Check safety equipment -Position of valve	Monthly	-Check pump damage -Check the pump lifting equipment for performance and smoothness
		Every 6 Months	-Check wear on pump impeller -Check Oil level and grease up -Check bearings
		Every 1~3 Year	-Check pump performance & wear on pump impeller
Monorail Motorized Hoist	-Check Smooth-Operation -Check all lifting equipment including wire and hook -Check lifting and traveling performance -Check safety equipment	Monthly	-Check End-stop system
		As needed basis	-Check traveling speed -Check hoist rails, structure & support -Check deflection of girder
Valves	-Check water leakage	As needed basis	-Check seal -Check damage

16.3 Operation and Maintenance practices (Mechanical)

The item of the main preservation work is shown below.

Name of Facility	Daily	Periodic	
	Point to be checked	**Frequency**	**Point to be checked**
1.HEAD WORKS/COARSE SCREEN INLET CHANNELS			
Coarse Screen	-Check Smooth-Operation -Check of the difference of the water level before and behind a screen -Remove un-removable floating matter on screens -Clean-up Top of Screen -Check abnormal noise -Check safety equipment -Check manual cleaning equipment Correctness	Monthly	-Check Screen-shape -Operation of a wiper -Adjustment of space between rakes and a screen -Check of the lubricating oil level of reduction gears -Check emergency stop system
Screenings Conveyor	-Check Smooth-Operation -Abnormal noise -Meandering of a belt	Weekly	-Check Grease up & Oils -Check emergency stop system
	Point to be checked	Frequency	**Point to be checked**
	-Check Smooth-Operation -Check scraper performance -Check rollers-performance -Cleaning of Conveyor -Check safety equipment	Monthly	-Check Damage to a belt -Check Slack of a belt& adjustment of take-up -Check Belt-speed
2. RAW SEWAGE PUMP STATION			
Raw Sewage Pump station	check for clogging & cleaning Check Smooth-Operation -Check discharge rate, pressure, abnormal noise, heat &vibration -Check liquid leakage -Check pump rotation direction -Check safety equipment	Daily Monthly	Check grease up & Oil level of reduction gears -Remove clogging & cleaning -Check emergency stop system
3.HEAD WORKS/GRIT BASINS			
Grit Collectors	-Abnormal noise -Check Smooth-Operation -Check safety equipment	Weekly	-Check grease up & Oil level of reduction gears -Remove scum& cleaning -Check emergency stop system
		Every 6 Months	-Check of shaft rotation speed
		Yearly	-Dry basins for checking of damage, space between rake and bottom floor, peripheral velocity, repair, painting & cleaning
Organic Return Pumps	-Check Smooth-Operation -Check discharge rate, pressure, abnormal noise, heat &vibration -Check liquid leakage -Check pump rotation direction -Check safety equipment	Monthly	-Clean up with water
		Every 6 Months	-Check pump damage - Check wear of pump impeller
		Every 1~3 Year	-Check pump performance & wear on pump impeller

Name of Facility	**Daily**	**Periodic**	
	Point to be checked	Frequency	**Point to be checked**
Grit Removal Equipment	-Check Smooth-Operation - Check discharge rate, abnormal noise -Check liquid leakage - Check safety equipment	Weekly	-Check grease up & Oil level of reduction gear box -Remove scum &cleaning -Clean up with water
		Monthly	-Check emergency stop system
		Every 6 Months	-Check of shaft speed - Check space between rake and bottom
Grit Conveyor	-Check Smooth-Operation - Abnormal noise - Meandering of a belt - Check Smooth-Operation - Check scraper performance -Check rollers-performance -Cleaning of Conveyor - Check safety equipment	Weekly	-Check grease up & Oils - Check emergency stop system
		Monthly	-Check damage to a belt -Check Slack of a belt& adjustment of take-up - Check Belt-speed
4. ANAEROBIC ZONE			
Anaerobic Tank Mixers	-Check mixing condition in the zone -Check abnormal noise - Check safety equipment	Every 6 Months	-Check the mixer lifting equipment for performance and smoothness -Check Mixer damage -Clean up with water
		Yearly	-Check smoothness of mixer operation - Check wear mixer impeller -Check Mixer speed &rotation direction
5. ANOXIC ZONE			
Anoxic Mixers	Ditto	Ditto	Ditto
6. AERATION ZONES			
Air Diffusers Assembly	-Check mixing condition in the zone - Check air flow rate & pressure	Every 6 Months	-Check the diffuser lifting equipment for performance and smoothness -Check diffusers Assembly

Name of Facility	Daily	Periodic	
	Point to be checked	Frequency	**Point to be checked**
		As needed basis	-Check the air flow rate and size of air babble - Check diffuser performance -Chemical cleaning for diffusers -Remove deposited material between diffuser and basin floor
Decanter	Check Smooth-Operation	weekly	Check performance
Mixed Liquor Recycle Pumps	-Check Smooth-Operation - Check discharge rate, pressure, abnormal noise - Check safety equipment	Monthly	-Check pump damage - Check the pump lifting equipment for performance and smoothness -Cleaning up with water
		Every 6 Months	-Check wear of pump impeller -Pump speed & rotation direction
		Every 1~3 Year	-Check pump performance
Monorail Motorized Hoist	-Check Smooth-Operation - Check all lifting equipment including wire and hook - Check lifting and traveling performance -Check safety equipment	Monthly	-Check End-stop system
		As needed basis	-Check traveling speed - Check hoist rails, structure & support
7. PROCESS AIR BLOWER BUILDING			
Air Blowers	-Check Smooth-Operation -Check discharge rate, pressure, abnormal noise, heat and vibration -Check blower speed &	Weekly	-Check grease up & Oil level of reduction gear box - Check safety equipment - Check Air filter -Check drain

Name of Facility	Daily	Periodic	
	Point to be checked	Frequency	**Point to be checked**
	rotation direction -Check coupling connection -Check cooling system -Check air leakage -Check safety equipment	Every 1~3 Year	-Check Blower performance
		As needed basis	-Check blower system -Check Silencers
EOT Crane/Hoist	-Check Smooth-Operation -Check all lifting equipment including wire and hook -Check lifting and traveling performance -Check abnormal noise & vibration -Check safety equipment	Monthly	-Check End-stop system
		As needed basis	-Check traveling speed -Check rails, structure & support -Check any damage
Alum Dispersion Raid Mixer	-Check coagulation condition in secondary clarifier -Check abnormal noise & vibration -Check safety equipment	Every 6 Months	-Check the mixer lifting equipment for performance and smoothness -Check Mixer damage
		Yearly	-Check smoothness of mixer operation -Check mixer speed & performance
8. CHEMICAL BUILDING (Alum Building)			
Alum Solution Tanks	-Check corrosion condition -Check leakage -Check drain & Over flow pipe	Weekly	-Remove deposition substance -Clean up tank &touch-uppainting
Alum Solution Tank Mixers	-Check Smooth-Operation -Check abnormal noise& vibration -Check mixing time -Check safety equipment	Weekly	-Clean up mixer

Name of Facility	Daily	Periodic	
	Point to be checked	Frequency	**Point to be checked**
		Monthly	-Check mixing speed - Check shaft and coupling connection
Alum Dosing Pumps	-Check Smooth-Operation -Check discharge rate, pressure, abnormal noise, heat and vibration - Check safety equipment	Monthly	-Check accuracy of flow rate -Clean up with water
		Every 1~3 Year	-Check pump performance
Flow Indicator	-Check flow indicator - Check safety equipment	Weekly	-Check accuracy of flow rate -Clean up with water
Monorail Motorized Hoist	-Check Smooth-Operation - Check all lifting equipment including wire and hook - Check lifting and traveling performance -Check safety equipment	Monthly	-Check End-stop system
		As needed basis	-Check traveling speed - Check hoist rails, structure & support
9. SLUDGE SUMP & PUMP STAION			
Sludge Pumps	-Check Smooth-Operation -Check discharge rate, pressure, abnormal noise, heat and vibration -Sludge leakage -Check safety equipment	Monthly	-Clean up with water
		Every 6 Months	-Check pump impeller - Check flow rate
		Every 1~3 Year	-Check pump performance
Monorail Motorized Hoist	-Check Smooth-Operation - Check all lifting equipment including wire and hook - Check lifting and traveling performance -Check safety equipment	Monthly	-Check End-stop system
		As needed basis	-Check traveling speed - Check hoist rails, structure & support
10.CHLORINE CONTACT TANK INLET CHANNEL			
Motored Chlorine Injectors (In-line)	-Check Smooth-Operation - Check mortar running - Check Chorine residual in chlorine contact tank	Weekly	-Check damage of chlorine gas supply line -Check back flow prevention valve

Name of Facility	Daily	Periodic	
	Point to be checked	Frequency	**Point to be checked**
	-Check abnormal noise & vibration -Check chlorine gas leakage by ammonia liquor -Check Gas pressure gauge, vacuum gauge, gas flow meter -Check safety equipment		-Check leakage of chlorine solution
		Yearly	-Check the injector maintenance lifting equipment for performance -Check in-line injector performance and smoothness
11. CHLORINE BUILDING			
Chlorinators	-Check solution leakage and/or chlorine gas -Check Gas pressure gauge, gas flow meter -Check dosing rate/amount -Check chlorine gas rate valves, check valves& pipe line -Check safety equipment	Weekly	-Check total System
Chorine Cylinders (Ton)	-Check chlorine gas / solution leakage -Check no gas leakage, and no wet or keep dray in the room -Check room temperature & humidity -Check Gas header, pipe line& gasket -Check safety equipment	Weekly	-Check Condition of the cylinder-material and Safety valve -Check storage way -Classification of cylinder as new or empty, and check the stock -Cleaning
Cylinder Scales	-Cleaning weight area	Weekly	-Check measuring error
Cylinder Lifting Equipment& Hoist	-Check Smooth-Operation -Check lifting equipment -Check lifting and traveling performance -Check safety equipment	Monthly	-Check End-stop system
		As needed basis	-Check traveling speed -Check hoist rails, structure & support

Name of Facility	Daily	Periodic	
	Point to be checked	Frequency	**Point to be checked**
Safety Equipment	-Check performance of chlorine gas detectors and sensors, Ventilation system - Check sequence of Auto / manual mode -Check safety equipment	Weekly	-Cleaning gas detector & sensors -Clean up the area installed detectors -Check safety shower performance
		Monthly	-Try-on oxygen mask, other safety appurtenances -Check Gas Leakage Repair Kits
Neutralization Equipment (Emergency Chlorine Scrubber)	-Check NaOH solution leakage from the tank /equipment /pipe/ valves - Check solution level-Check performance of splays, pumps -Check performance of exhaust blower -Check safety equipment	Weekly	-Check pH of NaOH solution
12.DISC CLOTH FILTER			
Disc Cloth Filter	Clogging & Cleaning	Weekly	Check pump performance Check total System
13.SLUDGE THICKENER			
Sludge Thickener	Clogging & Cleaning	Weekly	Check pump performance Check total System
14.CENTRIFUGE			
Centrifuge	Clogging & Cleaning	Weekly	Check pump performance Check total System

16.4 Operation & Maintenance practices (Electrical)

16.4.1 Typical items in Electrical Facility & their checks

Daily		Periodic	
Frequency	Description	Frequency	Description
Transformer	Verification of KVA, V, A, abnormal sound, current protection, oil temperature	Every 6 Months	Verification of general performance, Verification of oil levels , silica gel in breather , OLTC, OTI, WTI, Buchholz relay, CTs etc ,testing of oil ,verification of earth connections ,IR measurement .
HT Switchboard and Switchgears	Verification of kVA, kW,kWh V, A,PF, Hz, healthiness of protections ,indications, alarms, abnormal sound, burning smell .	Every 6 Months	Verification of condition of breakers, switches, relays, protective devices, earthing, wiring and connections.
PCC /MCCs/MLDB	Verification of V, A, healthiness of protections ,lamps, abnormal sound, burning smell	Every 6 Months	Verification of condition of breakers, switches, pushbuttons, relays, protective devices, earthing, wiring and connections
Variable Frequency Drives	Verification of Input & output voltage, current ,frequency. Verification of Indications , alarm & protections.	Every 6 Months	Verification of condition of breakers, switches, pushbuttons, relays, protective devices, earthing, wiring and connections. Verification of working of converter , inverter, DC Link . Verification of Harmonic Distortion.
Lighting panels	Verification of lamps, abnormal sound, burning smell.	Every 6 Months	Verification of condition of breakers, switches, earthing, wiring and connections.
Meters reading	Verification of V, Am, overload protection	Every 6 Months	Verification of over load protection indication, switch On/Off, accuracy, damage
Diesel Generator Set	1.Verification of Engine oil level, Engine oil leakage, air & oil filters, cooling fans, fuel level, water level etc. 2.Verification of battery voltage, charging & self start. 3.Verification of abnormal sound , vibrations etc. 4.Verification of Voltage, current, frequency, RPM, Indications, Alarms & Protections. 5.Verification of Oil leakage, fuel leakage . 6.Verification of Interconnecting Cable , earthing , loose connections etc .	Every 250hours/6 Months	1.Verification of Conditions of filters. 2.Verification of Condition of cooling fan. 3. Verification of Condition of battery & charger. 4.Verification of self start system 5.Verification of condition of engine ,alternator & accessories , doors of acoustic enclosure, exhaust system etc. 6.Verification of conditions of Breakers, Switches , Push Buttons , Relays etc. 7.Verification of Auto / Manual operation , all interlocks , synchronising . 8.Verification of Indications, Alarms & Protections . 7.Verification of Condition of Inter connecting Cables, Connection & earthing , including Neutral Earthing of AC Generator.

Cable system	Verification of short circuit, burning smell , loose connections, local heating	Every 6 Months	Verification of voltage drop, damage, insulation resistance
Lighting Fixtures	Verification of working of lamps & ballasts.	Every 6 Months	1. Verification of illumination level 2.Verification of condition of lamps & ballasts. 3. Cleaning of Lighting fixtures. 4. Verification of wiring .
Switch board	Verification of operation of switches , sockets .	Every 6 Months	1.Verification of condition of switches , sockets & fan regulators. 2. Verification of wiring .
Switch Socket	Verification of operation of Switch & Socket.	Every 6 Months	Verification of condition of Switch & Sockets
Ceiling Fan	Verification of operation of Fan.	Every 6 Months	1.Verification of condition of ceiling fan. 2.Verification of condition of bearing , abnormal sound /noise .
Power sockets	Verification of operation of MCB, Plug & Socket .	Every 6 Months	Verification of condition of MCB, Socket & Wiring .
General	1. Inspection of General appearance of various Electrical equipment /items . 2. Verification of Cable System for Short circuit , smell , damage etc.	Every 6 Months	1. Verification of condition of cables , wires& connections. 2. Verification of Insulation resistance of individual equipment , cables and total system. 3.Verification of Condition of Earth Connections.

16.4.2 Electrical System Operation Practices

- All the electrical equipments shall be handled and operated by a trained and authorized person only. All the equipment shall be checked for its proper earthing and loose connections prior to start the equipment. Naked wire, loose connections and faulty connections shall be repaired immediately prior to start for operation.
- Electrical sockets and switch shall not be touched by bare or wet hands. If there is any live wire found naked or on wet ground, main switch shall be turned off first then the wire shall be repaired or moved.
- For any electrical works proper insulated tools shall be used. Do not try to use tools made for other purpose; it may be hazardous.

16.5 Operation & Maintenance practices (Instrumentation, Control & Automation)

(a) General maintenance

A comprehensive maintenance program is critical to attaining long-term reliable performance of SCADA Systems / ICA systems. Periodic device calibration, preventive maintenance, and testing allow potential problems to be identified before they can cause mission failure. Prompt corrective maintenance assures reliability by minimizing downtime of redundant components.

The EPC or Turnkey contractor has to enter in to AMC contracts with system / equipment suppliers of ICA, as necessary. It is mandatory to enter into an agreement for a 7 years operation and maintenance contract with the instrumentation, PLC and SCADA system supplier and wireless communication supplier or the authorized system integrator, whosoever has executed the work for this project.

(b) Preventive maintenance

The SCADA system should be part of the overall preventive maintenance (PM) program for the facility. Table below provides a list of recommended maintenance activities and frequencies for ICA systems and their components.

Preventive maintenance schedules for ICA components and subsystems should be coordinated with those for the mechanical/electrical systems they serve to minimize overall scheduled down time.

Activity	Frequency
Pneumatic Systems/Components/Instruments	
Check Regulators and Filters	Monthly
Inspect Tubing and Piping	Monthly
Actuate Pressure Switches	3 months
Calibrate Switches and Sensors	Yearly
Calibrate Pressure Gauges	Yearly
Calibrate Level Transmitters	Yearly
Calibrate Flow transmitters	Yearly
Calibrate Pressure Transmitters	Yearly
Calibrate Thermometers	Yearly
Calibrate Analytical Instruments/Online Instruments (pH, ORP, Turbidity ,etc..)	6 Months
Change Sampling solution of Analytical Instruments	As required
Electronic Systems	
Lamp Test/Verify Indicators	Monthly
Inspect Enclosures for Dirt, Water, Heat	Monthly

Activity	Frequency
Run PLC Diagnostics	3 Months
Calibrate Sensors and Transmitters	Yearly
Calibrate Meters	Yearly
PLC Communication Modules	Monthly
PLC Batteries	Yearly
Test Automatic control Sequences	Monthly
Verify Alarms	Weekly
Software Maintenance and Patching	3months
Anti-virus Definition Updates	Monthly
Inspect Wire, Cable and Connections	Monthly
Inter site Communication Network	Weekly
Dead Bus Relays	3 Months
UPS setting with SCADA	Weekly
PLC Redundant Power back up	Monthly
SCADA Redundancy	Monthly
Network Redundancy	Weekly
PLC Hot-Standby	Monthly
Historian Package(Capacity)	Monthly
Data Archiving	Monthly

a. Many components of SCADA systems, such as dead-bus relays, are not required to function under normal system operating modes. For this reason the system should be tested periodically under actual or simulated contingency conditions. These tests should approach as closely as possible the actual off-normal conditions in which the system must operate.

For example, SCADA for Dual Redundant system should be tested by interrupting the utility source as far upstream of the normal service as possible.

b. Periodic system testing procedures can duplicate or be derived from the functional performance testing procedures.

c. The SCADA software maintenance should include timely updates of any new versions from the supplier and testing to verify proper installation on the SCADA computer. In addition, software antivirus updates should be maintained. This should be performed any time after the computer is connected to the Internet or the antivirus patch should be downloaded as and when the updates are available. Normal operation requires that the SCADA computer not be connected to the Internet.

Faulty Instruments, sensors, transmitters, communication modules, computer hardware should be replaced with new components. Repair of the items would not be accepted.

(c) Concurrent maintenance

Concurrent maintenance is defined as testing, troubleshooting, repair or replacement of a component or subsystem while redundant component(s) or subsystem(s) are serving the load. The ability to perform concurrent maintenance is critical to attaining the specified reliability/availability criteria for facilities and must be designed into the SCADA system. Where SCADA components are associated with equipment that has redundancy and therefore are not themselves redundant, their maintenance should be scheduled to occur during maintenance of the associated equipment. SCADA components and controllers that are redundant must be capable of being taken out of service, repaired or replaced and tested without interfering with the operation of the redundant component.

(d) Reliability centered maintenance

Reliability-Centered Maintenance (RCM) is an approach for developing an effective and efficient maintenance program based on the reliability characteristics of the constituent parts and subsystems, economics, and safety. RCM provides a logical, structured framework for determining the optimum mix of applicable and effective maintenance activities needed to sustain the operational reliability of systems and equipment while ensuring their safe and economical operation and support.

A significant byproduct of the application of SCADA systems to the control of facilities is the large amount of operational data made available through the trending and data storage features of the SCADA. This operational data can be used for automated performance monitoring of mechanical and electrical systems that can support a RCM approach

(e) Operations and maintenance documentation

The contractor should perform an O&M analysis to determine the O&M data required to support maintenance of the SCADA system . This analysis should be coordinated with Bangalore Development Authority (BDA) to determine maintenance parameters and O&M data that are available. Typical O&M data requirements include the following items:

a. System documentation as defined in FDS, FAT & SAT documents
b. Minimum spare parts list.
c. Recommended spare parts list.
d. Recommended onsite test equipment.
e. Recommended O&M training.
f. Recommended O&M to be performed by contractor

(f) Spare parts stocking

An adequate on-site stock of spare parts is essential to obtaining high availability of ICA systems.

All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labeled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

Minimum recommended stocking levels include the following. These quantities may need to be increased for components which are used in large numbers in the facility:

(1) Manufacturer's recommended spare parts list.
(2) One each of all line replaceable boards or modules.
(3) Six each power and control fuses used in the system.
(4) Tools required to terminate coaxial on fiber optic cables.

(g) Automation:

(1) Laptop computer loaded with software required to access controllers.
(2) Licenses for all software installed on the system.
(3) Permission to modify program code.
(4) Spare cables for connecting computer to controllers.
(5) PLC CPU, Power supply module,1 DI,DO,AI,AO modules, Communication module, protocol converter etc..
(6) PLC batteries, fuses, etc.

(h) Utilities & Consumables

The contractor has to provide consumables for printers e.g.: Ink cartridges (color & B/W), A4, A3, A1 size of paper, dot-matrix print paper for a period of 7 years.
Downtime of the above system should not exceed more than 2 hours.

(i) Technical support

The Contractor should specify functional areas of the operating system and/or equipment where a technical representative will be furnished by the manufacturer for training, test, checkout, validation, or pre-operational exercises.

Ongoing O&M of SCADA system software may require technical support from the system vendor or from agency technical personnel not located at the facility. Commercial SCADA software typically has provisions for remote modem access that permit this type of support from the vendor's location or an agency central engineering group.

Such remote access provisions represent a vulnerability to "hacking" and must be used with great caution. They should be monitored when in use and physically disconnected when not in use.

Password protection policies for all SCADA systems, including PLC's, shall be in compliance with Established policies and to be agreed with the employers representative.

These policies require that the default password that came from the control supplier be changed when Placed into operation at the facility.

Note:-

(a) During commissioning, Trial run and testing the Charges / Costs towards the following items shall be borne by the contractor.

- Network Operating charges for Wireless communication System (GPRS gateway)
- Software updates, consumables and stationeries etc..,
- Instrumentation (Analog) & Control Cables and Power Cables, OFC, etc. If any required.
- Painting for field Instrument enclosures.

(b) During O&M Period :

- Contractor can Quote Network Operating charges for Wireless communication (GPRS gateway) yearly wise.

16.6 Issue of Completion Certificate for Operation and Maintenance

The Employer shall issue a Completion Certificate for "Operation and Maintenance" after successful completion of O&M by Contractor to the satisfaction of the Employer.

End of Part 16

PART 17

HANDING OVER

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HANDING OVER 2

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PART 17
HANDING OVER

17.1 General

This section applies to procedure(s) on handing over the works and sites related to Sewage Treatment Plant back to the Employer at the end of 10 years period of operation and maintenance by the Contractor. This shall include all civil structures, mechanical systems including pumping main system, the instrumentation/control & automation system, communication system, electrical system including 11 kV/0.433kV substations, SCADA systems, all ancillary buildings and campus area.

The procedure for Handing Over shall include the final examination/tests of the system by the Engineer. O&M Contract Completion Certificate shall be issued by the Employer after the successful final examination/tests and submission of the relevant documents.

17.2 Duties and Responsibilities

1) All cost for the examination, tests and preparation of any documents of the activities shall be the Contractor's responsibility.

2) The Contractor shall provide all necessary labour, materials, and fuel required for tests.

3) Conduct Joint Inspection Prior to Contract Completion:
   To verify the condition of Works / Facilities at the end of 10 years of operation and maintenance for identifying damaged works, replacements and other works to be carried out to satisfy the requirements of Operation and Maintenance Plan, a joint inspection will be carried out by the Engineer, Employer and contractor.

4) Conduct Tests prior to Contract Completion:
   To verify the plant condition and performance of plants including pumps, blowers, valves, gates, cranes and other equipment at the end of 10 years of operation and maintenance, Contractor shall conduct all the required Tests prior to Contract Completion. The contractor is responsible to conduct annual inspections of cranes & other lifting equipment, pressure vessels and other equipment as required by law/Govt. of Karnataka.

   The inspection items are given below in Table 17.1 but not limited to this.

Table 17.1: Items to be examined at the End of 03 Years O&M Period

Items	Description
1. Appearance test /Visual examination (Damage/crack, differential settlement, soil settlement, peel off painting, missing/lost, leakage of water/solution/gas, corrosion, condition of structures, others)	- All Civil structures, building including interior/exte fence/gate, stairs, others - All Mechanical & Electrical equipment/accessories, others - All Pipe line valves and gates, others - All Instrumentation and Control equipment, others
2. Performance examination (Selection of operation mode, selection of facilities, flow/water level, overflow, vibration/noise level, speed of pump/motor, smoothness, gap/spaces, accuracy, setting value, condition of structures, others)	- Check Sequence, or Manual operation including water level, pressure sensors/protections, others - Check specification of all Mechanical equipment including pressure and water level gauges, pressure relief valves, others - Check specification of all Electrical equipment, others - Check specification of all Pipeline including valves, gates, others - Check specifications of all Instrumentation and Control equipment, others - Check specification of all accrual condition troubleshooting, others - Performance tests of pumps, blowers and other equipment
3. Verification of rectified works (System, leakage, crack, damage, soil settlement, corrosion, others)	- Check a list of all defect items, history, tendency, repeating, others - Check a list of all miss operation and maintenance items, others - Check all factors of defect / miss operation , others - Verification of action on the take measures, others - Verification of all rectified works with the reports and photo, others - Check emergency works and its factor, action plan, others - Check actual condition after rectified works, others
4. Operation skill (Staff member, others)	- Review of summary reports on O&M activities - Check time and motion of staff member, others - Interview operator regarding troubleshooting, others - Paper test (basic knowledge, calculation of chemical dosing, safety, others) - Field test (using/put on the safety gear, drill of chl leakage accident, others)
5. Waste Water analysis (Sampling and analysis, others)	- Location of sampling and time, and date - Raw sewage and treated sewage - All each process - Authorized certificate
6. O/M Record	Check inventory list (parts, chemical, reagent, others) - Check the quantity of inventory, others - Check maintenance tools and equipment, vehicle, others
7. Spare parts and others	- Check inventory list (parts, chemical, reagent, others) - Check the quantity of inventory, others - Check maintenance tools and equipment, vehicle, others

Items	Description
7. Sludge Handling/Disposal	Dumping Yard Location Details Log Book Trip sheet Sale particulars: Photographs / Video

5) Submission of the report on completion of O&M Contract:

The Contractor shall submit the completion report after pass the final examination/tests. The report shall consist of relevant documents, for request for issue the Completion certificate of 5 years O&M period, which is given below in Table 17.2 but not limited to this.

Table17.2: Documents to be handed over at the End of 03Years O&M Period

Contents	Description
1. Outline	Outline - Summary of project, scope of work, location of project, main component with specification, others
2. Completion Photographs (At acceptance complete inspection, completion inspection and final\ inspection)	Photographs with short description - Civil (structural, buildings, others) - Mechanical, Electrical and I&C (equipment, facility, others) - Piping works
3. Inspection summary (At acceptance complete inspection, completion inspection and final inspection)	Appearance test /Visual/ Performance examination - Table of Summary of test activity based on daily and monthly - List of type of test, date, inspector, evaluation, comments - Civil (name of structure, drawing no., drawings, design dimension, previous dimension, actual dimension, others) - Mechanical (name of facility and equipment, tag no., quantity, others) - Electrical (name of facility and equipment, tag no., quantity, others) - Instrumentation and Control (name of facility and equipment, tag no., quantity, others)
4. Main inspection data (At construction)	Summary of data with graphic /chart - Civil (plate load bearing test, compressive strength test, water retaining test, compaction field test, road construction works in STP, hydrostatic test, others) - Mechanical (disinfection test, others) - Electrical (earthing resistance test, others) - Instrumentation and Control
5. Inspection record (At acceptancecomplete inspection, completion inspection and final inspection)	Appearance test /Visual/ Performance examination/ Verification of rectified works - Civil (Refer to Table 17.1, point no.1,2,3) - Mechanical (Refer to Table 17.1, point no.1,2,3) - Electrical (Refer to Table 17.1, point no.1,2,3) - Instrumentation and Control (Refer to Table 17.1, point No. 1,2,3)
6. Training and commissioning record (At first and second	- Summary (Schedule of training and commissioning, attendance rate, impression on training program) - Training attendance list (participants, trainings date, others)

Contents	Description
training program)	- Commissioning daily record (Sewage flow rate of designed and actual, name of operated facility, list of measurement and its time and reading value, raw sewage and treated sewage quality, value of V/A/kW of each equipment, others) - Photographs with short description
7. Sewage quality certification Data (At acceptance complete inspection, completion inspection and final inspection)	- Location of sampling and time, and date - Raw sewage and treated sewage - All Unit Process - Issued from Authorized certificate
8. Operation and Maintenance manual (Civil, Mechanical, Electrical and Instrumentation & Control)	Updated O&M Manual
9. O/M records	- Water quality analysis and production of electricity - Sludge and screenings handling amount - List of O/M record, Ledger and operation record - Various types of Ledgers and other plant organization charts and plant management records including cost and expenditure - History of troubleshooting - O/M record of a process, unit operation and equipment - Mechanical (name of parts, tag no., quantity, location of stock, others) - Electrical (name of parts, tag no., quantity, location of stock, others) - Pipes & fittings (name of parts, tag no., quantity, location of stock, others) - Valve & Gates (name of parts, tag no., quantity, location of stock, others) - Instrumentation & Control (name of parts, tag no., quantity, location of stock, others) - Others (name of parts, tag no., quantity, location of stock, others)
10 . Spare parts list	- Mechanical (name of parts, tag no., quantity, location of stock, others) - Electrical (name of parts, tag no., quantity, location of stock, others) - Pipes & fittings (name of parts, tag no., quantity, location of stock, others) - Valve & Gates (name of parts, tag no., quantity, location of stock, others) - Instrumentation & Control (name of parts, tag no., quantity, location of stock, others) - Safety equipment and devices including for staff and for testing - Others (name of parts, tag no., quantity, location of stock, others)

Contents	Description
11 . Key list with boxes	- - Name of key, location, tag no., quantity, Civil (all related material: reinforcement bar, cement, aggregate, sand, gravel, asphalt, crashed stone, chemical admixture, waterreducing agent, pozzolana, water-tightness sheet,construction equipment, manhole, water-resistant coating, paint, windows, door, others) - Mechanical (all related equipment; screens, pumps, blowers, Chlorinators, scarper, conveyor, hopper, central drive & rotating mechanisms, pipes, valves, gates, pressure gauges, safety valves, safety equipment, flow meters, coating, painting, others) - Electrical (all related equipment: electrical wire, electrical conduit, motor, control panel, relay, transformer, heater, generator and silencer, timer, breaker, light/lamp, switch, street light, earthing, measurement equipment, air condition, communication equipment, electric pole, coating painting, ventilation fan, air duct, others) - Instrumentation & Control (all related equipment, others) - Safety equipment - Others
12. Manufacture produced Catalogue (Civil, Mechanical, Electrical and Instrumentation & Control)	- Civil (all related material: reinforcement bar, cement, aggregate, sand, gravel, asphalt, crashed stone, chemical admixture, water reducing agent, pozzolana, water-tightness sheet, construction equipment, manhole, water-resistant coating, paint, windows, door, others) - Mechanical (all related equipment; screens, pumps, blowers, Chlorinators, Disc cloth filters, sludge dryer, COTDM, scarper, conveyor, hopper, central drive & rotating mechanisms, pipes, valves, gates, pressure gauges, safety valves, safety equipment, flow meters, coating, painting, others) - Electrical (all related equipment: electrical wire, electrical conduit, motor, control panel, relay, transformer, heater, generator and silencer, timer, breaker, light/lamp, switch, street light, earthing, measurement equipment, air condition, communication equipment, electric pole, coating painting, ventilation fan, air duct, others) - Instrumentation & Control (all related equipment, others) - Safety equipment - Others
13.Instruction manual (Civil, Mechanical, Electrical and Instrumentation & Control)	- See above (11)
14.Factory inspection record or Quality assurance (Civil, Mechanical, Electrical and Instrumentation & Control)	- Civil (all related material: reinforcement bar, cement, aggregate, sand, gravel, asphalt, crashed stone, chemical admixture, water reducing agent, pozzolana, water-tightness sheet, construction equipment, manhole, water-resistant coating, paint, windows, door, others) - Mechanical (all related equipment; screens, pumps, blowers, Chlorinators, Disc cloth filters, sludge dryer, COTDM, scarper, conveyor, hopper, central drive & rotating mechanisms, pipes, valves, gates, pressure gauges, safety valves, safety equipment, flow meters, coating, painting, others) - Electrical (all related equipment: electrical wire, electrical conduit, motor, control panel, relay, transformer, heater,

Contents	Description
	generator and silencer, timer, breaker, light/lamp, switch, street light, earthing, measurement equipment, air condition, communication equipment, electric pole, coating painting, ventilation fan, air duct, others) - Instrumentation & Control (all related equipment, others) - Safety equipment - Others
	History of construction
15. Photograph (During Construction, at defect liability, at joint completion inspection) (Civil, Mechanical, Electrical, Instrumentation & Control)	Replacement of defect liability - Civil: construction site before starting construction, earthwork, arrangement of bar, cleaning before placing, formwork, concrete mixing work, placing, vibrating, curing, remove of formwork, backfill, compaction, all field inspection and lab test, others - Mechanical: inspection at factory, receiving inspection, completion inspection, all field inspection and lab. test, others - Electrical: inspection at factory, receiving inspection, completion inspection, all field inspection and lab. test, others - Instrumentation and Control: inspection at factory, receiving inspection, completion inspection, all field inspection and lab. test, others
16. Production samples (Civil, Mechanical, and Instrumentation & Control)	All samples for technical approval - Attach Analytical instruments name, approved sign of the Engineer.
17. Report	- Monthly and Annual report - Others

These data shall be provided both in soft and hard copies, in proper professional format.

17.3 Specifications

The specification of materials used for repairs shall be the same as have been used in the original work. Specifications for any materials which were not used during construction shall be approved by the Engineer prior to Handing Over.

17.4 Check List

17.4.1 General

Within the framework of the Contractor's responsibilities given above, the Contractor shall carry out the following activities. However, these shall not limit the requirement for other activities which otherwise are required as per terms and conditions of the Contract or to fulfill the Contractor's responsibilities or are essential as per good industrial practices. The Contractor shall hand over all the components of works in good working condition for the following, but not limited to:

a) All pumps, motors and other mechanical equipment etc., at the sewage treatment plant and Terminal Sewage Pumping Stations (all works constructed in this Contract).

b) All required consumables required for functioning of plant with inventory of material.

c) All Electrical Equipments such as Transformers, HT Metal Enclosed Switchboards (11kV) & Switchgears, 415 V metal enclosed switchgears (PCC/MCC), 415 V Power capacitor and control panel, Diesel Standby Generator with AMF Control Panel and Synchronizing panel, Battery, battery charger and DC Distribution Board, Variable Frequency Drives, Non Segregated Bus Duct ,Power & control cables, Cable carrier system, Lighting system , Earthing and lightning protection systems of the Plant (All works constructed in this Contract).

d) All Instrumentation and control equipment etc., at the pumping stations (All works constructed in this Contract).

e) Administrative buildings etc. at the pumping stations (All works constructed in this Contract) in neat and clean condition.

f) AMC contracts with system / equipment suppliers, as necessary for PLC and SCADA system supplier or the authorized system integrator as executed the work for this project.

g) Lighting fixtures and the lighting system of all areas and replacement of all nonfunctional lighting fixtures.

h) Records for the followings but not limited to

- Water quality report
- Repair history of all mechanical, electrical and instrumentation control equipment in sewage treatment plant and Terminal Sewage Pumping Stations, and communication instruments;
- Logbooks through PLC system;
- Daily log of operations of all the important equipment with time tag;
- Hourly readings of water levels, pressure sensors, flow rates and integrated quantity of water;
- Operation al cost;
- Monthly Running hours of the all Mechanical equipment and total electrical power consumption;
- Generator running hour and production of electricity
- Sludge and screenings handling amount
- Daily list of alarms with time tag; (Power consumption by each Pump and each Pump House)
- Logbook format and the data to be included in the logbook;
- Last periodic maintenance done for all equipment/buildings of the system;

i) Required spares, general and special tools & tackles, test equipment and adequate inventory of required accessories or equipment itself for repair/replacement of defective electrical, mechanical, instrumentation and control system, pipe, and the communication system. However at the end of the Contract, the Contractor shall hand over the full spares, tools and tackles as supplied with the Contract by replacing the used items with fresh supplies of the same specifications.

j) Repair of the roads, buildings and campus area utilities.

k) Drinking water supply facilities at treatment plant and sewage pumping stations and all its units.

l) Record of stores for the electrical, mechanical and instrumentation and control equipment as well as that for consumables. The records will include but shall not be limited to:
- Materials received and issued for works;
- Proper arrangement of material in stores to ensure its safety and easy availability;
- Maintaining store areas in a neat and tidy condition;
- Keeping records and accounting for the incoming materials,
- Keeping records and accounting for the consumed materials.

m) Structures/buildings of campus areas of Sewage Treatment Plant and Terminal Sewage Pumping Stations and others built in the Contract must ensure adequate cleanliness, ventilation, illumination and structural safety. In addition to this, the general hygienic standards must be in acceptable condition and adequate plantation, horticultural activities must be well maintained to give pleasant environment of the campus / building.

n) Updated operation and maintenance manual as defined in specifications for O&M works.

m) 6 sets of Hard Copies and 2 sets of Soft copies of all "As Commissioned Final Drawings".

17.4.2 Sewage Pumping Stations

The Contractor shall hand over all components of the works in good working condition for the following, but not limited to:

i) All facilities from inlet gate/valve to reservoirs, to pumps, motors, valves, cranes, flow meters, compressor room, PLC control, Transformers, HT Metal Enclosed Switchboards & Switchgears (11kV), 415 V metal enclosed switchgears (PCC /MCC), 415 V Power capacitor and control panel, Battery, battery charger and DC Distribution Board, Variable Frequency Drives, Non Segregated Bus Duct ,Power & control cables, Cable carrier system, Lighting system , Earthing and lightning protection systems of the Terminal Sewage Pumping Station (All works constructed in this Contract).

ii) PLC, including the hardware, software and all instruments, in good working condition**.**

iii) Entire control system and instruments as per the contract and manufacturer's recommendations.

v) Replacement of damaged controls, communication cables and power supply cables.

vi) Repair or replacement, as required, of all instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches along with all other equipment.

vii) Calibration of all measuring/metering equipment or as recommended by the manufacturer. The calibration at manufacturer's works shall be done in case of major failure/ repairs of the instruments.

viii) Submission of daily and monthly customized reports produced by the local SCADA system.

ix) To provide all required consumables for a period of –12 months.

x) Repair of damaged moving parts, steel structures, and the RCC structure. Subsequently the repairs, cleaning disinfection and painting of all civil works must have been done.

xi) Lubrication of all gears, motors, motorized valves, gates and other parts of the system.

xii) Check all valves and gates for their manual and electric operation. Operation of valves must be checked from local control console, switchgear and through PLC system. Any defect observed must be made good.

xiii) Make good all circuits and buildings, all electrical, mechanical and instrumentation equipment, substation equipment, lighting, DG Set and earthing system associated including replacement, if any (as required).

xiv) Painting of the exposed mild steel components of pipeline, ladders, railings etc. must be done.

xv) Make good landscaping of the surrounding areas of the pumping stations, free from shrubs, weeds, grass and other unwanted vegetation.

xvi) Ensure safety accessories, e.g. gloves, shoes, first aid box, etc.

xviii) Ensuring fire and safety equipment.

17.4.3. Lubrication

The Contractor, in the operation and maintenance manuals, shall furnish a complete schedule of recommended oils, grease, and other required lubricants.

The Contractor shall indicate the brand name of indigenously available equivalent lubricants, with their complete duty specifications, in the O&M manual. The Contractor shall also furnish the schedule of quantities for each fill, frequency of filling and annual requirement in O&M manual.

Where lubrication is effected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month. Where more than one type of special grease is required, a grease gun for each special type shall be provided for the usage.

17.4.4 Spare Parts

All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labeled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

17.4.5 Electrical System

The Contractor shall hand over the following at the end of Operation and Maintenance Period:

(i) Revised as built drawings based on all modifications during O&M Period. All Electrical Drawings like Single Line Diagrams, Control Circuits Equipment Layout, Cable Layout, and Cable Schedules, Lighting Layouts, Earthing Layouts etc., should be maintained and handed over.

(ii) Details of Protective Relay Settings and time relay settings including any changes done during the Operation and Maintenance period, Details of Oil Changes /Filtration of Transformers, Records of any changes made in the System during the Operation and Maintenance period etc should be maintained.

(iii) Equipment wise maintenance record during O&M Period, as per daily checking out/inspection and regular (every 6 months or 12 months).

(iv) Motor wise Power consumption Details and over all power consumption detail of plant.

(v) Details of IR Test of all Equipments like, HT/LT Switchgear Panels, Diesel Generators, Transformers and Cables etc should be maintained.

(vi) Log book showing details Electrical faults that have occurred in the plant and record of corrective actions taken during O&M period.

(vii) Equipment wise technical data given by equipment supplier, Documents showing Bill of Materials and Operation & Maintenance Manual (hard copy or soft copy).

(viii) List of mandatory spares that are to be maintained at stores and their actual availability in plant, if it is below same has to be replenished.

(ix) Details of Measurement of Earth resistance, Earth Pit wise and Overall Values during the O&M Period.

(x) Details of Illumination Levels during the O&M Period along with details of changes, if any effected during the O&M period.

17.4.6. Electrical Checks to be done during handover after O&M Period

(i) Contractor to provide a test schedule & format to be approved by engineer before commencing any test.

(ii) Checking of all electrical equipment, items etc as per bill of materials. Visual checking and tracing out the circuit based on revised as built drawings.

(iii) Physical Operational checks of all Equipment & Protections have to be done.

(iv) Power frequency voltage tests & IR measurement for various electrical equipment, items& cables to be done.

(v) Testing of transformer oil samples.

(vi) Measurement of earth resistance for individual earthing system & overall for the installation.

(vii) Checking of Lightning Protection System.

(viii) Measurement of illumination level at various premises.

(ix) If any item is found to be faulty during the above checks/tests the same shall be rectified/replaced as necessary.

17.4.7. Instrumentation, Control and Automation System

The Contractor shall hand over the following documents/manuals/programs at the end of Operation and Maintenance Period for STP under this contract:

i. Detailed drawings and O&M manuals of all the Instruments, Panels, Valve Actuators, Field Instruments etc supplied under IC&A package of the contract.

ii. Detailed drawing and manual of the PLC installed .Manual shall include the PLC series installed along with complete details on I/O modules, Ethernet switch, Relay modules, and converters (if any).

iii. A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the PLC and accessories installed illustrated with examples. This shall be provided along with the standard manufacturer's literature.

iv. A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the SCADA and accessories installed, illustrated with examples .This shall be provided along with the standard manufacturer's literature.

v. A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the interface control panel to Cauvery Bhavan, illustrated with examples .This shall be provided along with the standard manufacturer's literature.

vi. Interoperability testing tool/software shall be provided along with relevant manuals and operating instruction with examples.

vii. Latest PLC program back-up, SCADA software back-up with license, SCADA database backup, reports and alarm back-up, Historical archived data containing reports and alarms and configuration set-up shall be provided.

viii. All softwares used under ICA shall be handed over along with their original licenses.

ix. Complete list of database /addresses shall be provided clearly indicating the spare tags for PLC, SCADA software..

x. List of mandatory spares that are to be maintained at stores for complete ICA package and their actual availability in plant, has to be provided.

xi. Any password's set to access the internal PLC program; interface control panel shall be provided and demonstrated.

xii. All passwords (PLC, Interface control panel & SCADA and other software/hardware) shall be provided in a sealed envelope and addressed to the Chief Engineer (K).

xiii. PLC, SCADA package shall be updated with the latest software version/ patch before handing over. The same has to be demonstrated to the engineer.

xiv. Latest licensed version of windows operating system along with MS–Office or equivalent software which is prevailing at that point of time shall be installed on SCADA machines and other machines installed and integrated with the SCADA package. The same shall be demonstrated to the engineer.

xv. Contractor shall conduct an adequate training session for the client's staff which shall include PLC configuration, trouble shooting techniques, SCADA configuration and troubleshooting techniques, diagnostic techniques and trouble shooting techniques for wireless technology employed for communication.

xvi. The training session shall be of duration of minimum Five (5) working days at a stretch.

xvii. Manufacturer's literature/Manuals for flow meters, level transmitters, switches, pressure transmitters etc and analytical instruments installed.

xviii. Instrument wise, PLC and SCADA wise maintenance records of complete O&M period shall be provided.

xix. A complete and updated list of all manufacturers/system integrators/contractors of ICA with contact numbers shall be provided. The same shall also be made available on site for ready reference.

xx. The final as commissioned versions of all drawings of ICA, which will include cable termination details, I/O mapping, database details etc shall be provided in PDF format and editable format and loaded in the operator machine available on site. The same shall be demonstrated to the engineer.

17.4.8. ICA Checks to be done during handover after O&M Period for STP under this contract

(i) Contractor to provide a test schedule and format to be approved by the engineer before commencing any of the tests.

(ii) Functional Checking of all Laboratory instruments and ICA equipment including flow meters, pressure and level instruments, vibration monitoring instruments, and wireless equipment being used for communication.

(iii) Loop checks will be conducted.

(iv) All instrument cabling shall be inspected for continuity. If found faulty, the same shall be replaced and demonstrated.

(v) All instrumentation cable conduits shall be checked for damage. If found faulty , they should be rectified or replaced and sealed to the satisfaction of the engineer

(vi) Visual operational checks of all the Panels including PLC panel, SCADA system, and interface control panel, and Surge Control Panel.

(vii) Licensing feature of PLC, SCADA software and hardware shall be demonstrated.

(viii) Functional check of set points change at HMI/SCADA and it's downloading to PLC's concerned.

(ix) Hot-standby feature of PLC and hot swappable feature of I/O modules shall be demonstrated. If found to be faulty/non-operational, shall be rectified and if required replaced to normal working condition and demonstrated to the client.

(x) Dual-redundant server feature of SCADA shall be demonstrated. If found to be faulty/non-operational, shall be rectified and if required replaced to normal working condition and demonstrated to the client..??

(xi) Functional check of data received/transmitted from remote stations shall be conducted in conjunction with SCADA.

(xii) Functional check of interface control panel to Cauvery Bhavan in conjunction with Master SCADA center at Cauvery Bhavan shall be conducted.

(xiii) Historical archiving of all data shall be demonstrated.

(xiv) Availability of memory for smooth operation of PLC, SCADA machines shall be demonstrated. If found to be in-adequate, the same shall be rectified /archived and demonstrated.

(xv) If any instruments and automation equipment are found to be faulty during the above tests, the same shall be rectified or replaced as necessary.

17.4.9. Sewage Treatment Plant Ancillary Works

(i) Make gardens and plantation in the campus area green, neat and tidy with removal of shrubs, weeds, grass and unwanted vegetation and make pruning, trimming and cutting of old big trees from the Plant Area along with.

(ii) Reinstate the roads and lighting fixtures and lighting circuits in campus to it original state.

(iii) Make good and in working condition for lighting fixtures and lighting circuits, water supply facilities in Treatment plant, Sewage Pumping Stations, offices and other buildings.

(iv) The Contractor shall carry out ordinary repairs to buildings. The repairs may include but not limited to the following items:

  (a) Easing of doors and windows, monsoon repairs to roofs, attention to drains, rain water spouts, attention to plinth protection.

  (b) External white or color wash, external or internal painting, internal distempering, renewal of approach roads within the campus.

(v) Any faults in the electric installation, leakages, earthing, exposed wire ends and any hazards on this account to the users/inmates of the buildings, should be taken care of suitably, wiring, which is damaged or outlived, should be replaced.

(vi) Damaged sanitary lines should be replaced and choked lines cleared.

(vii) Proper drainage of the area around the building should be ensured to avoid stagnation of rain water/ house effluent, in order to prevent malarial conditions. Where courtyards exist in the buildings, their drainage into the outer drains should be ensured. Any choked drains should be cleared properly.

(viii) Leaking roofs should be attended to immediately with suitable repairs/ treatment, as the case may be. The rain waterspouts should also be cleared of blockages, etc. The roof should be swept clean of leaves, debris, etc., if any.

(ix) The plaster on outer walls of the building, which is exposed to weather, should be repaired before rains in order to prevent dampness inside. Where plinth protection has been provided, it should be checked and the damaged portions, if any, should be repaired before rains.

(x) Damaged flooring should be repaired/ replaced as per requirement, in order to prevent dampness inside the rooms, etc. during rains.

(xi) Repairs of damaged floors, door/window fittings, water taps, water coolers, furniture, desert coolers, electric circuits, must be taken up on complaints using the material of same quality as used during construction.

(xii) Pump House ventilation system to be checked for effective heat dissipation from the Pump Motors and Electrical Equipments.

17.4.10. Wireless Communication System

(i) Make good a wireless communication system to ensure reliable and easy communication to and from STP under this contract. Make good a wireless communication system to ensure reliable and easy communication to and from STP and Master SCADA control center at Cauvery Bhavan.

(ii) Replacement of batteries, faulty sets and all other non-functional equipment to ensure trouble free communication if required.

17.4.11.Completion Documents

Completion (Handing over) documents shall include on a minimum 3 sets of softcopies and 3 sets of hard copies. The hard copies shall be spiral bounded clearly indicating the version/revision submitted. All the contents shall be indexed. The contents of completion documents shall be clearly legible and shall include original manufacturer's literature on a minimum, and in-corporate any changes as per site conditions.

The comprehensive updated operation and maintenance manuals (six sets) shall be submitted at the end of the operation and maintenance period. It shall be updated based on the principals broadly listed in Part-16.

17.4.12. As-Built Drawings

Revised As-built drawings based on all modifications during O&M Period shall be submitted at the end of O&M period. It shall include all drawings of treatment units(plan and all necessary sections), utility and ancillary buildings, site layout of treatment plant and pumping stations, drawing of pump house, layout of pumps and all other mechanical equipment and piping, all electrical drawings like Single Line Diagrams, Schematic Diagrams, Control Circuits Equipment Layout, Cable Layout& Cable Schedules, Earthing Layouts and all ICA Drawings like P&ID, System configuration diagram (PLC & SCADA architecture), Instrument installation drawings, Instrument cable schedule, and cable layouts. Six sets of the revised as-built drawings shall be submitted in hardcopies and softcopies (editable form).

17.4.13. Prices

The Contractor, at the time of bidding, will be responsible to ensure the completeness and adequacy of his Bid Price to fulfill the entire responsibilities as described above. His bid price, as quoted on a yearly basis in the Schedule of Prices, shall include all costs for handing over.

17.4.14. Completion certificate for O&M Contract

1. The Contractor on completion of O&M period will request the Employer for a joint inspection of the Plant, after ensuring that all the Plant equipments are in good handing over condition and all the requirements/documents as specified in this contract are also ready for handing over.
2. Based on above request a Joint Inspection with Engineer shall be arranged by the Contractor to assess the condition of civil structure, mechanical, electrical and instrumentation equipment and First Joint Inspection Report**,** for various required remedial actions, repair actions, replacement actions, tests etc. shall be prepared.
3. The Contractor shall attend to all points of Joint Inspection Report, by carrying out all such remedial/repair/replacement actions, tests at his own cost, and after attending, will confirm the same to the Employer.
4. On receipt of the confirmation as above 3, Second Joint Inspection shall be arranged by the Contractor, for certification of completeness of remedial work, as well as condition of all civil works to its original appearance.
5. The Contractor shall submit the entire required documents to Employer for review and comments. The Contractor shall resubmit the documents incorporating the comments.
6. The Employer shall issue the Completion Certificate of the O&M Contract to the Contractor within 30 days of acceptance of Second Joint Inspection Report, subject to the above documents and obligation are met by the Contractor before 90 days prior to handing over of the plant.

End of Part 17

SECTION 7C

GEO-TECHNICAL INVESTIGATION REPORT

SECTION 7A: FORM OF TECHNICAL PROPOSAL

SECTION 7A: FORM OF TECHNICAL PROPOSAL

NAME OF THE CONTRACT : Design, Construction & Commissioning of 75 MLD (25 MLD and 50 MLD) Capacity Sewage Treatment Plant (STP) using Sequential Batch Reactor (SBR) Process Technology with Biological Nutrient, Nitrogen & Phosphorous Removal System including 6 Nos., of RCC Wet Well Cum Pump house and 8 Nos of Machine hole Pumping Stations with All Electro-Mechanical Instrumentation, SCADA and allied Civil Works for Dr. K.Shivarama Karantha Layout, Bengaluru including Five Years of O & M during operation Period

To:
Executive Engineer ,Division 1,BDA-DSKL
Bangalore Development Authority
Kumara park west T Chowdaiah Road,
Bangalore 560 020,
Karnataka (India)

Gentlemen:

We have examined the Conditions of Contract, Employer's requirements (technical Specifications), Technical Schedules, Addenda Nos. _____ (*Insert nos.*), clarifications and the matters set out in the tender documents. We have understood and checked these documents and have not found any errors in them. We accordingly offer to design, construct, execute and complete and also operate and maintain the said Works and remedy any defects therein, in conformity with these documents and the enclosed Proposal. [*The following sentence is for Joint Ventures only*]. We hereby confirm that all partners of the joint venture are jointly and severally liable for execution of the Contract in accordance with the terms and conditions of the Contract.

We shall confirm all works, Plants, units, equipment including piping shall be designed as per the Technical specification given in NIT in complete manner without any deviation.

We further undertake, if invited to do so by you, and at our own cost, to attend a clarification meeting at a place of your choice, for the purpose of reviewing our Technical Proposal and duly noting all amendments and additions thereto, and noting omissions there from that you may require, and to submit additional information that you require without any change to our price proposal as submitted with our tender or substance of the tender, in accordance with clause 22.1 of the ITT.

We are, Gentlemen

Yours faithfully

Signature _____ in the capacity of _____ duly authorized to sign bids for and on behalf of _____

Address:

Date:

SECTION 7B: TECHNICAL SCHEDULES

INDEX TO TECHNICAL SCHEDULES

Preamble to Section 7B Technical Schedules

Schedule No.	**Particulars**
I	Not Used
II	Construction Programme
III	Proposed Plant Details
IV	Instrumentation and Control Equipments
V	Electrical Works
VI	Operating Details
VII	Subcontractors
VIII	Quality Assurance and Quality Control Plan
IX	Environmental Management Plan
X	Safety Plan
XI	Functional Guarantees of the Plant
XII	Confirmation of Purchase and Compliance of Standard Basic Specifications (Civil and Structural Works) and (Electrical, Mechanical, Instrumentation and Control Works) for Sewage Treatment Plants Contracts

TECHNICAL SCHEDULES

PREAMBLE TO TECHNICAL SCHEDULES

1. Tenderers are required to provide full and complete information as detailed in the following Schedules. All Schedules are required to be completed, but Tenderers should not necessarily restrict themselves to using the space that is provided; Tenderers will be responsible for providing additional sheets/pages and/or supplementary information wherever necessary to fully communicate the required information. The information will be examined to assess the capability of the tenderer to carry out the work in accordance with the requirements of the Contract.

2. In the event that any particular Schedule or item in the Schedule is not applicable, the Tenderer shall clearly indicate the same and provide full and complete justification regarding why it is not applicable.

3. The Employer wishes to clarify that regardless of what is proposed by the Tenderer, the successful Tenderer shall be required to conform in all respects to the requirements of the Contract, and all proposals shall be subject to the approval of the Engineer. Acceptance of the Tenderer's proposal for the purposes of tender evaluation shall not be construed as approval by the Employer. All details will subsequently be subject to the approval of the Engineer during execution of the Contract. **No claim for additional payments shall be entertained, other than in accordance with the Contract.**
   The Tenderer shall note that, pursuant to Sub-Clause 14.2 of Section 2, Instructions to Tenderers, Tenderer is required to affix Tenderer's seal and authorized signature on all pages of this Section 7B, Technical Schedules.

TECHNICAL SCHEDULE II

CONSTRUCTION PROGRAMME

(To be completed by the Tenderer)

Name of the Tenderer

The Tenderer shall submit a realistic construction programme which he proposes to adopt for executing the Works. This shall be in sufficient detail so as to show the order and duration of key activities required to carry out the Works (including each stage of mobilization of labour, setting up of site offices/ workshops/ consents and approvals, procurement, manufacture, pre-delivery inspection and testing, delivery to Site, construction, erection, testing, commissioning and operation and maintenance).

The Tenderer should pay particular attention to ensuring that the proposed programme is integrated with the Method Statement.

The construction programme shall be developed and presented on a commercially available project management software (such as Primavera, MS Project or equivalent), together with bar charts and CPM and PERT diagrams which clearly illustrate the critical path to achieve the desired results.

TECHNICAL SCHEDULE III

PROPOSED PLANT DETAILS
(To be completed by the Bidder- Use Separate Schedule for 25 MLD and 50 MLD STP)

3.1.1 Mechanical Works For Dr Shivarama Karatha Layout – 25 MLD STP (SBR With BNR)

3.1.2 Mechanical - Coarse Screens & Fine Screens

S. No.	Description	Units	Particulars	
			Coarse	**Fine**
(a)	**General**			
	(i) Make			
	(ii) Model			
	(iii) Quantity (W+S)	Nos.		
	(iv) Type			
	(v) Auto jam removal system		Yes/No	Yes/No
(b)	**Screen**			
	(i) Clear Spacing	mm		
	(ii) Width	mm		
	(iii) Height	mm		
	(iv) Raking speed	m/min		
	(v) Motor rating	kW		
	(vi) Water Level	m		
(c)	**Materials of Construction** (i) Frame			
	(ii) Rake carriage			
	(iii) Screen bars			
	(iv) Fasteners			
	(v) Canopy			
(d)	**Belt Conveyor System**			
	(i) Material of belt			
	(ii) Width of conveyor	mm		
	(iii) Speed of conveyor	m/sec		
	(iv) Thickness of belt and ply rating			
	(v) Make of the belt			
	(vi) Motor rating	kW		
	(vii) Safety device			
(e)	**Screw Conveyor System**			
	(i) Make			

	(ii) Material			

S. No.	Description	Units	Particulars	
			Coarse	**Fine**
	(iii) Speed	rpm		
	(iv) Motor rating	kW		
	(v) Size of screw	mm		
	(vi) Angle of screw	deg		
(f)	**Unit Control Panel** (i) Make			
	(ii) Over all dimensions	m x m x m		
	(iii) Degree of protection			
	(iv) Timer • Make • Type			

3.1.3 Raw Sewage Pump Station:

S. No.	Description		Units	Particulars		
(a)	(i)	Wet well capacity	cum			
	(ii)	Wet well Dimensions	mm			
(b)	**Pump**					
	(i)	Pump Make				
	(ii)	Type				
	(iii)	Model				
	(iv)	Quantity (W+S)	Nos.			
	(v)	Capacity	m^3/s			
	(vi)	Head	m			
	(vii)	Shut off Head	metres			
	(viii)	NPSH required	metres			
	(ix)	Submergence required	metres			
	(x)	Efficiency	%			
	(xi)	Absorbed power at duty point	kW			
	(xii)	Motor rating	kW			
	(xiii)	Speed	rpm			
(c)	**Material of construction:**					
	(i)	Casing				
	(ii)	Impeller				
	(iii)	Shaft				

	(iv)	Mechanical Seal				
	(v)	Lifting Chain and				

S. No.	Description		Units	Particulars		
		Guide Bar				
	(vi)	Cooling Jacket				
	(vii)	Discharge size	mm			
	(viii)	Suction size	mm			
	(ix)	Flange Drilling standard:				
	(x)	Weight (Pump + Motor)	kgs			
(d)	**Testing & Inspection:**					
	(i)	Pump performance testing standard				
	(ii)	Maximum Noise level	dB(A)			
	(iii)	Maximum velocity of vibration	mm/sec			
(e)	**Motor :**					
	(i)	Make				
	(ii)	Type				
	(iii)	Model				
	(iv)	Quantity (W+S)				
	(v)	Rating	kW			
	(vi)	Weight	kgs			

3.1.4 Vortex Type Grit Removing Equipment

S. No.	Description	Units	Particulars	
(a)	**General**			
	(i) Make			
	(ii) Model			
	(iii) Quantity (W+S)			
	(iv) Type			
(b)	**Reduction Gear**			
	(i) Make			
	(ii) Type			
(c)	**Drive Motor**			
	(i) Make			
	(ii) Speed	rpm		
	(iii) Rating	kW		
(d)	**Materials of Construction**			

	(i) Paddle Agitator			
	(ii) Frame			

S. No.	Description	Units	Particulars	
	(iii) Walkway			
(e)	**Screw Classifier Mechanism** (i) Make			
	(ii) Type			
	(iii) Peripheral velocity	m/sec		
	(iii) Size of the Equipment • Diameter • Height	 mm mm		
	(iv) Drive System • Make of reduction gear • Make of motor			
	(v) Material of Screw			
	(vi) Safety device			
	(vii) Width/diameter of conveyor	mm		
	(ix) Speed of Classifier	m/sec		
	(x) Motor rating	kW		
(g)	**Organic Vane Return Pumpset** (i) Make &Type of • Pump • Motor			
	(ii) Motor rating	kW		
	(iii) Materials of Construction • Casing • Impeller • Shaft • Seal			
(h)	**Air Lift Pump**			
	(i) Make			
	(ii) Type			
	(iii) Rating	kW		

	(iv) Material of Construction - Casing - Impeller - Shaft			

3.1.5 Air Blower for Vortex Type Grit Removing Equipment

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos.	
	(iv) Capacity at NTP	m^3/min	
	(v) Design maximum discharge pressure	mlc	
	(vi) Efficiency	%	
	(vii) Speed, blower	rpm	
	(viii) Absorbed power	kW	
	(ix) Motor rating	kW	
	(x) Speed, motor	rpm	
	(xi) Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	(xii) Vibration	mm/sec	
	(xiii) With Acoustic Hood	dB(A)	
	(xiv) Without Acoustic Hood	dB(A)	
	(xv) Weight – Blower	kgs	
	(xvi) Maximum lifting weight	kgs	
	(xvii) Dimensions (L x W x H)	m x m x m	
	(xviii) Coupling Type		
	(xix) Coupling Make		
	(xx) Cooling System		
(b)	**Material of construction:**		
	(i) Casing		
	(ii) Impeller		
	(iii) Shaft		
	(iv) Common Base frame		
	(v) Orientation		
(c)	**Acoustic Hood:**		
	(i) Type		
	(ii) Material of Construction		
(d)	**Inlet/Outlet silencer**		

	(i) Type		
	(ii) Make		
	(iii) Filter media		
	(iv) Mean air velocity	m/s	
(e)	**Noise reduction (mean) Air release valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	

S. No.	Description	Units	Particulars
	(iii) Type		
	(iv) Set pressure	bar	
	(v) Make		
(f)	**Delivery non-return valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Make		
(g)	**Delivery isolation valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Make		

3.1.6 Submersible Mixer

S. No.	Description	Units	Particulars				
			Anaerobic Zone	**Anoxic Zone**	**Sludge Sump**		
(a)	**Submersible Mixer**						
	(i) Make						
	(ii) Type						
	(iii) Model						
	(iv) Quantity (W+S)	Nos.					
(b)	**Material of construction**						
	(i) Casing						
	(ii) Impeller						
	(iii) Shaft						
	(iv) Mechanical						

	(v) Guide mechanism with winch						
	(vi) Wire Rope						
	(vii) Lifting Davit						
(c)	**Design/Construction features**						
	(i) Impeller Diameter	mm					
	(ii) Rotation speed	rpm					
	(iii) Immersion	mm					

S. No.	**Description**	**Units**	**Particulars**				
			Anaerobic Zone	**Anoxic Zone**	**Sludge Sump**		
	depth						
	(iv) Absorbed power	kW					
	(v) Motor rating	kW					
	(vi) Maximum Lifting weight	kgs					

3.1.7 SBR Unit:

Tender to Specify and include all relevant information

S. No.	**Description**		**Units**	**Particulars**
	SBR Unit: Pumps/Blower/Diffuser/Decanters			
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity		
	(v)	Capacity		
	(vi)	Pump Details		
	(vii)	Blower Details		
	(viii)	Valves Details		
	(ix)	Diffusers Details		
	(x)	Decanter Details		

3.1.8 Fine Bubble Air Diffusers

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Diffuser OD x Length	mm x mm	
	(v) Aeration/SBR Basin Dimensions (L x W x SWD)	mm x mm	

S. No.	Description	Units	Particulars
	(vi) Design Air-Flow per Aeration/SBR Basin (Maximum/Average)	Nm^3/hr	
	(vii) Quantity per Aeration/SBR Basin	No.	
	(viii) Quantity in Aeration Basin Zone 1/Zone 2/...	No.	
	(ix) Weight per Diffuser	Kg	
	(x) Design air flow per diffuser	m^3/hr	
	(xi) Efficiency per diffuser	%	
(b)	**Diffuser Membrane**		
	(i) Type-self cleaning (Yes/No)		
	(ii) No. of Membranes - Total	No.	
	(iii) Membrane Material		
	(iv) Means of attachment		
	(v) Membrane OD X Length	mm x mm	
	(vi) Pore size (Average)	mm	
	(vii) No. of Pores per length of Diffuser	No./m	
	(viii) Bubble size (Avg)	mm	
(c)	**Diffuser Assembly**		
	(i) Make		
	(ii) Type		
	(iii) Length x Width	mm x mm	
	(iv) Material of Construction		

	(v) Coupling Type • Make • Model/Size		
	(vi) Diffuser Assembly Weight	Kg	
(d)	**Materials of Construction**		
	(i) Diffuser Tube		
	(ii) Membrane		
	(iii) Pipe clamps & Hardware		
	(iv) Pipe Grid		
(e)	**Performance**		
	(i) SOTE Oxygen transfer rate • Clear water • Field	%	

S. No.	Description	Units	Particulars
	(ii) Zone of influence	m	
	(iii) Zone of oxygenation	m	
	(iv) Depth of mixing	m	
	(v) Velocity thro' the Diffuser	m/sec	
	- Diffuser Head loss & Efficiency V/s Submergence - Curve attached Diffuser Grid Drawing with retrievable arrangement details attached	Yes/No Yes/No	

3.1.9 Process Air Blowers

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	Nos.	
	(iv) Capacity at NTP	m^3/min	
	(v) Design maximum discharge pressure	mlc	
	(vi) Efficiency	%	
	(vii) Speed, blower	rpm	
	(viii) Absorbed power	kW	
	(ix) Motor rating	kW	

	(x) Speed, motor	rpm	
	(xi) Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	(xii) Vibration	mm/sec	
	(xiii) With Acoustic Hood	dB(A)	
	(xiv) Without Acoustic Hood	dB(A)	
	(xv) Weight – Blower	kgs	
	(xvi) Maximum lifting weight	kgs	
	(xvii) Dimensions (L x W x H)	m x m x m	
	(xviii) Coupling Type		
	(xix) Coupling Make		
	(xx) Cooling System		
(b)	**Material of construction:**		
	(i) Casing		
	(ii) Impeller		
	(iii) Shaft		
	(iv) Common Base frame		

S. No.	Description	Units	Particulars
	(v) Orientation		
(c)	**Acoustic Hood:**		
	(i) Type		
	(ii) Material of Construction		
(d)	**Inlet/Outlet silencer**		
	(i) Type		
	(ii) Make		
	(iii) Filter media		
	(iv) Mean air velocity	m/s	
(e)	**Noise reduction (mean) Air release valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Set pressure	bar	
	(v) Make		
(f)	**Delivery non-return valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Make		
(g)	**Delivery isolation valves**		
	(i) Number	Nos.	
	(ii) Diameter	mm	
	(iii) Type		
	(iv) Make		

3.1.10 Induction Motor for Process Air Blowers

Sr. No.	Description	Unit	Particulars
(a)	Make		
(b)	Type Designation		
(c)	Rating	kW	
(d)	Particulars at rated voltage and frequency :		
(I)	Starting time	Sec.	
(II)	Starting current	% FL	
(III)	Pull-out torque	% FLT	
(IV)	Pull-up torque	% FLT	

Sr. No.	Description	Unit	Particulars
(e)	Minimum voltage required under starting conditions to accelerate driven equipment to rated speed.	Volts	
(f)	Starting time at specified minimum starting voltage	Sec.	
(g)	Permissible running time at full load at minimum allowable voltage	Min.	
(h)	Locked rotor current withstand time (safe stall time) at 110% rated voltage		
(i)	At rated temp. (Hot)	Sec.	
(ii)	When cold	Sec.	
(i)	Stator thermal time constant	Sec.	
(j) (i)	Permissible no. of equally spread starts per hour under normal service conditions	No.	
(ii)	Permissible no. of starts in quick succession with cold machine at room temperature	No.	
(iii)	Permissible no. of hot restarts	No.	

(iv)	Starts per 8 hour period and 24 hour period	No.	
(k)	Space Heaters :		
(i)	Rated voltage, no. and location	Volts	
(ii)	Rating (Total)	KW	
(l)	Terminal box:		
(i)	Fault withstand capacity at rated voltage and duration	MVA for Secs.	
(m)	Insulation treatment		
(n)	**Embedded temperature detectors**		
(i)	Make & Type		
(ii)	Number		
(iii)	Resistance at 0^{o} C	Ohm	
(o)	**Efficiency**		
(i)	Full Load		
(ii)	$^{3}/_{4}$ Load		

Sr. No.	**Description**	**Unit**	**Particulars**
(iii)	$^{1}/_{2}$ Load		
(iv)	At duty point		
(p)	**Power factor**		
(i)	Full Load		
(ii)	$^{3}/_{4}$ Load		
(iii)	$^{1}/_{2}$ load		
(q)	Total guaranteed losses comprising iron loss, copper loss, friction, windage and stray losses	kW	
(i)	Break up : Iron loss	kW	
(ii)	Copper loss	kW	
(iii)	Friction, windage and stray losses	kW	
(r)	**Motor bearings**		
(i)	Permissible temperature rise for bearings	^{o} C	
(ii)	Design ambient temperature assumed for above	^{o} C	
(s)	Motor bearing lubrication system self lubrication / forced oil lubrication		
(t)	**Stator core temperature detectors**		

(i) (ii) (iii)	Type and Make		
	Number		
	Resistance at 0^{o} C	Ohm	
(u)	Permissible vibraton limits	mm/sec	
(v)	Wr^2 Value	kg-m^2	
(w)	Weight	Kg	

3.1.11 Mixed Liquor Recycle Pump set

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	No.s	
	(v) Tubular Installation		Yes/No

S. No.	Description	Units	Particulars
(b)	**Performance**		
	(i) Capacity	cu.m/hr	
	(ii) Total head	m	
	(iii) Speed	rpm	
	(iv) Overall efficiency (Pump + Motor)	%	
	(v) Motor Rating	kW	
(c)	**Materials of Construction**		
	(i) Impeller		
	(ii) Casing		
	(iii) Shaft		
	(iv) Mechanical seal		
	(v) Delivery pipe and diameter		
	(vi) Guide wire/rope & Lifting Chain		
	(vii) Dia of the tube/pipe & MOC		
(d)	Weight	Kg	
(e)	Accessories as specified (Provided / Not provided)		
(f)	Testing & Inspection:		

	(i) Pump performance testing standard		
	(ii) Maximum Noise level	dB(A)	
	(iii) Maximum velocity of vibration	mm/sec	

3.1.12 Alum Dosing Pumps

S. No.	Description	Units	Particulars
(a)	**Pumps**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)		
	(iv) Model		
	(v) Capacity max/min	l/s	
	(vi) Head	mlc	
	(vii) Stroke adjustment	mm	
	(viii) Stroking speed max/min	spm	
	(ix) Casing material		
	(x) Diaphragm material		
	(xi) Shaft material		

S. No.	Description	Units	Particulars
	(xiii) Motor rating	kW	
	(xiv) Motor Make		
(b)	**Alum preparation Tank:**		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	nos	
	(iv) Size (Diameter x Height)	m x m	
	(v) Material of construction		
(c)	**Alum solution mixer**:		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	nos	
	(v) Motor rating	kW	
	(vi) Motor speed	rpm	
	(vii) Mixer speed	rpm	
	(viii) Impeller material		
	(ix) Shaft material		

3.1.13 Chlorination System

S.No.	Description	Units	Particulars
(a)	**Automatic Changeover Device**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)		
	(iv) Model		
(b)	**Chlorinator**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)		
	(iv) Model		
	(v) Max capacity	kg/hr	
	(vi) Min Capacity	kg/hr	
	(vii) Accuracy as a percent of actual rate in the operating range	±%	
	(viii) Details of Instruments mounted		
	(ix) Cabinet Material		
(c)	**Chlorine load Cell (weighing scale)**		
	(i) Make		

S.No.	Description	Units	Particulars
	(ii) Type		
	(iii) Range		
	(iv) Quantity (W+S)		
(d)	**Chlorine leak detector**		
	(i) Make		
	(ii) Type		
	(iii) Range		
	(iv) Quantity (W+S)		
	(v) Location		
	(vi) Adjustable range of Alarm		
	(vii) State whether separate alarms for leak detection and leak detector equipment failure are provided		
(e)	**Chlorine Tonners and Roller supports**		
	(i) Make		
	(ii) Type		

	(iii) Quantity (W+S) - Chlorine tonners - Roller supports	Nos	
	(iv) Tonner capacity	Kgs	
	(v) Material of construction:		
	Body		
	Rollers		
	Bush		
(f)	**Liquid Chlorine Pipe work, valves and fittings:**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	nos	
	(iv) Rating		
(g)	**Material of construction:**		
	(i) Pipe		
	(ii) Fittings		
	(iii) Valves		
	(iv) Type		
	(v) Body		
	(vi) Shaft		
	(vii) Plug/Disc/Diaphragm		
(h)	**Valve Actuator:**		
	(i) Make		
	(ii) Type		
	(iii) Model		
(i)	**Pressure Gauges:**		

S.No.	Description	Units	Particulars
	(i) Make		
	(ii) Type		
	(iii) Range		
(j)	**Gas Chlorine Pipe work, valves and fittings:**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)		
	(iv) Rating		
(k)	**Material of construction:**		
	(i) Pipe		
	(ii) Fittings		
	(iii) Valves		
	(iv) Type		

	(v) Quantity		
	(vi) Body		
	(vii) Shaft		
	(viii) Plug/Disc/Diaphragm		
(l)	**Valve Actuator:**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	nos	
	(iv) Model		
(m)	**Pressure Gauges:**		
	(i) Make		
	(ii) Type		
	(iii) Range		
(n)	**Chlorine Ejectors:**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	nos	
	(iv) Model	Nos.	
	(v) Rating		
	(vi) Material of construction :		
	(vii) End connections		
(o)	**Tonner lifting Beam with Hooks**		
	(i) Make		
	(ii) Quantity (W+S)		
	(iii) Material of construction		
(p)	**Chlorine Tonner weighing equipment**		
	(i) Make		
	(ii) Type		

S.No.	Description	Units	Particulars
	(iii) Quantity (W+S)		
	(iv) Range		
	(v) Accuracy		
(q)	**Safety Equipment:**		
	(i) Make:		
	(ii) Quantity:		
	(iii) Type:		
	(iv) Self contained breathing apparatus quantity		
	(v) Positive air-line breathing apparatus quantity		
	(vi) Instant action resuscitators quantity		

	(vii) Safety clothing complete set quantity		
	(viii) Emergency showers quantity		
	(ix) Eye Baths quantity		
	(x) Portable compressor, recharging cylinder, quick release coupling complete set quantity		
(r)	**Chlorine Gas scrubber :**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Quantity (W+S)		
	(v) MOC of Tower		
	(vi) Weight	kg	
	(vii) Capacity	Kgs	
	(viii) Caustic pump capacity/head	Cum/hr/ m	
	(ix) Type & Make		
	(x) Motor Rating	kW	
	(xi) MOC of Caustic Pump		
	- Casing		
	- Impeller		
	- Shaft		
	(xii) Blower capacity/pressure	Cum/hr/ bar	
	(xiii) Type & Make		
	(xiv) MOC of Blower		
	- Casing		
	- Impeller		
	- Shaft		
	(xv) Agitator in the tank		Yes/No

S.No.	Description	Units	Particulars
	(xvi) Type & Make		
	(xvii) MOC of agitator		
	(xviii) Motor Rating	kW	

3.1.14 Chlorine Booster Pump

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		

	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	No.s	
(b)	**Performance**		
	(i) Capacity	cum/hr	
	(ii) Total head	m	
	(iii) Speed	rpm	
	(iv) Overall efficiency (Pump + Motor)	%	
	(v) Motor Rating	kW	
(c)	**Materials of Construction**		
	(i) Casing		
	(ii) Impeller		
	(iii) Shaft		
	(iv) Shaft Sleeve		
	(v) Mechanical Seal		
	(vi) Base Plate		
	(vii) Delivery pipe and diameter		
(d)	Weight	Kgs	
(e)	**Testing & Inspection:**		
	(i) Pump performance testing standard		
	(ii) Maximum Noise level	dB(A)	
	(iii) Maximum velocity of vibration	mm/sec	

3.1.15 Chlorine Building Ventilation

S. No.	Description	Units	Particulars
	Chlorine cylinder room		
(a)	**Exhaust fans:**		
	(i) Make		
	(ii) Model		
	(iii) Quantity(W+S)		
	(iv) Capacity	m^3/s	
	(v) Speed	rpm	
	(vi) Motor rating	kW	
(b)	**Ducting :**		
	(i) Standard		
	(ii) Type		
	(iii) Dimension	m x m	
	(iv) Material		
(c)	**Chlorinator Room:**		
	(i) Exhaust fans		
	(ii) Make		
	(iii) Model		
	(iv) Quantity (W+S)		
	(v) Capacity	m^3/s	
	(vi) Speed	rpm	
	(vii) Motor rating	kW	
(d)	**Ducting :**		
	(i) Standard		
	(ii) Type		
	(iii) Dimension	m x m	
	(iv) Material		

3.1.16 EOT Crane

S. No.	Description	Units	Particulars		
(a)	**EOT Crane**		**Process Air Blower Room**	**Chlorination Room**	
	(i) Make				
	(ii) Type and class				
	(iii) Safe working Load	tonne			
	(iv) Hoist speed high/low	m/min			
	(v) Long Travel speed	m/min			
	(vi) Cross travel speed	m/min			

S. No.	Description	Units	Particulars		
	(vii) Span	m			
(b)	**Hoisting Rope:**				
	(i) Diameter	mm			
	(ii) Construction				
	(iii) Quality of steel				
	(iv) Minimum Breaking Load	kgs			
	(v) Factor of safety				
(c)	**Motors for Hoist/Long travel/cross travel :**				
	(i) Make				
	(ii) Type				
	(iii) Rating	kW			
(d)	**Details of Brakes for Hoist/cross travel/Long travel:**				
	(i) Make				
	Design Holding Torque	N-mm			
	(iii) Net weight	kgs			

3.1.17 Electric Hoist

S. No.	Description	Units	Particulars			
(a)	**Electric Hoist**		**Pump Area**			
	(i) Make					
	(ii) Type and class					
	(iii) Safe working Load	tonne				
	(iv) Hoist speed high/low	m/min				
	(v) Cross travel speed	m/min				
	(vi) Span	m				
(b)	**Hoisting Rope:**					
	(i) Diameter	mm				
	(ii) Construction					
	(iii) Quality of steel					
	(iv) Minimum Breaking Load	kgs				
	(v) Factor of safety					

S. No.	Description	Units	Particulars			
(c)	**Motors for Hoist/ cross travel :**					
	(i) Make					
	(ii) Type					
	(iii) Rating	kW				
(d)	**Details of Brakes for Hoist/cross travel:**					
	(i) Make					
	(ii) Design Holding Torque	N-mm				
	(iii) Net weight	kgs				

3.1.18 Manual Hoists

Sr. No.	Description	Particulars							
		Sludge PS	**Plant Water Ps**	**Plant Drain Ps**					
(a)	Capacity (tonnes)								
(b)	Quantity								
(c)	Class								
(d)	Lift (m)								
(e)	Span (m)								
(f)	Length of the runway (m)								
(g)	Hook type / Construction								
	- I.S. Specification No.								
	- Swivel type								
(h)	Wire rope construction and standard								
(i)	Specification/ Type of Rails for Long Travel								
(j)	**Painting**								
	- Type of primer								

Sr. No.	Description	Particulars							
		Sludge PS	**Plant Water Ps**	**Plant Drain Ps**					
	coat								
	- No. of coats of paint								

3.1.19 Submersible Pump Set

S. No.	Description		Units	Particulars		
				Plant Water	**Plant Drain**	
(a)	(i)	Tank capacity	cum			
	(ii)	Tank Dimensions	mm			
(b)	**Pump**					
	(i)	Pump Make				
	(ii)	Type				
	(iii)	Model				
	(iv)	Quantity (W+S)	Nos.			
	(v)	Capacity	m^3/s			
	(vi)	Head	m			
	(vii)	Shut off Head	metres			
	(viii)	NPSH required	metres			
	(ix)	Submergence required	metres			
	(x)	Efficiency	%			
	(xi)	Absorbed power at duty point	kW			
	(xii)	Motor rating	kW			
	(xiii)	Speed	rpm			
(c)	**Material of construction:**					
	(i)	Casing				
	(ii)	Impeller				
	(iii)	Shaft				
	(iv)	Mechanical Seal				
	(v)	Lifting Chain and Guide Bar				
	(vi)	Cooling Jacket				
	(vii)	Discharge size	mm			
	(viii)	Suction size	mm			
	(ix)	Flange Drilling standard:				
	(x)	Weight (Pump + Motor)	kgs			

S. No.	Description		Units	Particulars		
				Plant Water	**Plant Drain**	
(d)	**Testing & Inspection:**					
	(i)	Pump performance testing standard				
	(ii)	Maximum Noise level	dB(A)			
	(iii)	Maximum velocity of vibration	mm/sec			
(e)	**Motor :**					
	(i)	Make				
	(ii)	Type				
	(iii)	Model				
	(iv)	Quantity (W+S)				
	(v)	Rating	kW			
	(vi)	Weight	kgs			

3.1.20 Gates +

S. No.	Description	Units	Particulars
(a)	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)		
	(iv) Service		
	(v) Type		
	(vi) Spindle Type		
	(vii) Size	mm x mm	
	(viii) Weight	kgs	
	(ix) Seating Head	m	
	(x) Unseating Head	m	
(b)	**Material of construction:**		
	(i) Wall Thimble		
	(ii) Gate		
	(iii) Frame		
	(iv) Spindle		
	(v) Stem coupling		
	(vi) Seating face		
	(vii) Wedge		
	(viii) Headstock		
	(ix) Gear House cover & stem guide		
	(x) Lift Nut		
	(xi) Fasteners & Anchors		
	(xii) Lifting mechanism, Gear House & stem guide		

S. No.	Description	Units	Particulars
(c)	**Gate Actuators +**		
	(i) Make		
	(ii) Type		
	(iii Model		
	(iv Service		
	(v) Number	Nos	
	(vi Motor Rating	kw	
	(vi Motor speed	rpm	
	(vi Protection		
	(ix Gear Reducer Make		
	(x) Type		

+Bidder to provide above details for each size of Gate and Service including modulating type of gates

3.1.21 Valves #

S. No.	Description	Units	Particulars
(a)	**Butterfly valves :#**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Quantity (W+S)	Nos.	
	(vi) Size	mm	
	(vii) Rating	PN	
	(viii) Test pressure	bar	
	Material of construction		
	(ix) Body		
	(x) Disc		
	(xi) Sealing face		
	(xii) Shaft		
	Gear Reducers		
	(i) Make		
	(ii) Material		
	(iii) Flange Drilling standard		
(b)	**Butterfly Valve Actuators #**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Quantity (W+S)	Nos.	
	(vi) Motor rating	kW	
	(vii) Design Torque	N-m	
	(viii) Time for full open to full close	seconds	

S. No.	Description	Units	Particulars
(c)	**Plug valve**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Quantity (W+S)	Nos.	
	(vi) Size	mm	
	(vii) Rating	PN	
	(viii) Test pressure	bar	
	(ix) Body material		
(d)	**Non-return valves #**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Quantity (W+S)	Nos.	
	(vi) Size	mm	
	(vii) Rating	PN	
	(viii) Test Pressure	bar	
	(ix) Design standard		
	(x) Flange drilling standard		
(e)	**Material of construction:**		
	(i) Body		
	(ii) Disc/plates		
	(iii) Spring		
	(iv) Shaft		
(f)	**Sluice valves :#**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Number	Nos	
	(vi) Size	mm	
	(vii) Rating	PN	
	(viii) Test pressure	bar	
	Material of construction		
	(ix) Body		
	(x) Gate		
	(xi) Sealing face		
	(xii) Shaft		
	Gear Reducers		
	(i) Make		
	(ii) Material		

S. No.	Description	Units	Particulars
	(iii) Flange Drilling standard		
(g)	**Sluice Valve Actuators #**		
	(i) Make		
	(ii) Type		
	(iii) Number		
	(iv) Motor rating	kW	
	(v) Design Torque	N-m	
	(vi) Time for full open to full close	seconds	
(h)	**Knife Gate valves :#**		
	(i) Make		
	(ii) Type		
	(iii) Model		
	(iv) Service		
	(v) Number		
	(vi) Size	mm	
	(vii) Rating	PN	
	(viii) Test pressure	bar	
	(ix) Body material		
	(x) gate material		
	(xi) Sealing face material		
	(xii) Shaft material		
	(xiv) Gear Reducers :		
	(xv) Make		
	(xvi) Material		
	(xvii) Flange Drilling standard		
(i)	**Knife Gate Valve Actuators #**		
	(i) Make		
	(ii) Type		
	(iii) Number		
	(iv) Motor rating	kW	
	(v) Design Torque	kg-m	
	(vi) Time for full open to full close	seconds	
(j)	**Telescopic valve**		
	(i) Make		
	(ii) Quantity (W+S)	Nos.	
	(iii) Type		
	(iv) Pressure rating	PN	
	(v) Diameter /size	m	
	(vi) End connection		
	(vii) Material of construction:		
	(viii) Valve Body		
	(ix) Spindle		

S. No.	Description	Units	Particulars
	(x) Disc/gate		
	(xi) Lining		
	(xii) Fasteners		

Bidder to provide above details for each size, type of Valve and Service

3.1.22 Sludge Pumps

S. No.	Description	Units	Particulars		
			Sludge Sump		
(a)	(i) Make				
	(ii) Type				
	(iii) Model				
	(iv) Quantity (W+S)				
	(v) Capacity	cum/hr			
	(vi) Head	m			
	(vii) Efficiency	%			
	(viii) Max. solid size	mm			
	(ix) Speed	rpm			
	(x) Motor rating	kW			
(b)	**Material of construction :**				
	(i) Casing				
	(ii) Rotor				
	(iii) Stator				
	(iv) Line shaft				
	(v) Sealing				
	(vi) Base Plate				
(c)	**Construction Features**				
	(i) Protection				
	(ii) Flange drilling standard				
	(iii) Suction diameter	mm			
	(iv) Discharge diameter	mm			
	(v) Coupling type/make				
(d)	**Motor**				
	(i) Make				
	(ii) Motor rating	kW			
	(iii) Motor speed	rpm			
	(v) Insulation class				
	(vi) Enclosure				
	(vii) Voltage & Frequency				

3.1.23 Polyelectrolyte Dosing Pumps

S. No.	Description	Units	Particulars
(a)	**Pumps**		
	(i) Make		
	(ii) Type		
	(iii) Quantity (W+S)	nos	
	(iv) Model		
	(v) Capacity max/min	l/s	
	(vi) Head	m	
	(vii) Stroke adjustment	mm	
	(viii) Stroking speed max/min	spm	
	(ix) Casing material		
	(x) Diaphragm material		
	(xi) Shaft material		
	(xiii) Motor rating	kW	
	(xiv) Motor Make		
(b)	**Polyelectrolyte preparation Tank:**		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)		
	(iv) Size (Diameter x Height)	m x m	
	(v) Material of construction		
(c)	**Poly solution Agitator**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)		
	(v) Motor rating	kW	
	(vi) Motor speed	rpm	
	(vii) Mixer speed	rpm	
	(viii) Impeller material		
	(ix) Shaft material		
	(x) Solids recovery		

3.1.24 Belt Conveyor system

S. No.	Description	Units	Particulars
(a)	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	nos	

S. No.	Description	Units	Particulars
	(v) Capacity	Kgs/min.	
	(vi) Length of conveyor	m	
	(vii) Angle of Inclination		
	(viii) Belt width	mm	
	(ix) Jointing detail/type		
	(x) Belt rating		
	(xi) Belt speed		
	(xiii) Belt scraper-Type / No.		
(b)	**Motor**		
	(i) Make	`	
	(ii) Rating	kW	
	(iii) Speed	rpm	
	(iv) Insulation class		
	(v) Enclosure		
	(vi) Voltage & Frequency		

3.1.25 Air-conditioning Equipment (For SCADA Room)

S. No.	Description	Units	Particulars
(a)	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Capacity	TR	
	(v) Quantity	Nos.	
	(vi) Motor Rating	kW	
	(vii) Air-Ducting :		
	(viii) Material		
	(ix) Size		
	(x) Quantity		
	(xi) Whether all the required accessories are provided	Yes/No	

3.1.26 Disc Cloth filter

Tender to Specify and include all relevant information

S. No.	Description		Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity		
	(v)	Capacity		
	(vi)	Others Details		

3.1.27 Sludge Thickener Unit

Tender to Specify and include all relevant information

S. No.	Description		Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity		
	(v)	Capacity		
	(vi)	Others Details		

3.1.28 Centrifuge Unit

Tender to Specify and include all relevant information

S. No.	Description		Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity (W+S)		
	(v)	Motor rating		
	(vi)	Motor speed		
	(vii)	Centrifuge Force		
	(viii)	Solid Discharge Type		
	(ix)	Impeller material		
	(x)	Shaft material		
	(xi)	Others Details		

Note: 1) All Equipment shall be of reputed make and shall qualify the criteria clause no 8.40 of part 8 of this Bid document.

2) Any equipment not listed above, but found essential for successful commissioning & operation of the project. Tendere shall include the same and furnish the details in the above mentioned format.

Note: All Equipment shall be of reputed make and shall qualify the criteria clause no 8.40 of part 8 of this Bid document.

3.3 Process and CIVIL Units

S. No.	Units	STP
3.4.1	**General and Process for STP**	
(a)	Total head loss (m) in STP (from water level in Coarse screen inlet channel of STP to water level in effluent channel of chlorine contact tank) at peak flow with one unit of each process with multiple units out of service	
3.4.2	**Sewage Treatment Plant**	
(a)	Receiving Chamber	
(i)	No. of units	
(ii)	Capacity of each unit (MLD)	
(iii)	Size of chamber, L*B*D (m)	
(iv)	Max, Average, and Min water levels (m)	
(v)	Head loss (m)	
(b)	Coarse Screen Influent Channel & Chamber	
	(i) Size of channel, L*B*D (m)	
	(ii) Size of incoming pumping / gravity main (m)	
	(iii) No. and size of gated openings weir gates	
	(iv) Max, Average, and Min water levels (m)	
(c)	Raw Sewage Pump station	
	(i) No. of units	
	(ii) Capacity (MLD)	
	(iii) Wet Well Dia (m)	
	(iv) Depth of Well (m.)	
	(v) Max, Average, and Min water levels (m)	
(d)	Inlet Chamber	
(i)	No. of units	
(ii)	Capacity (MLD)	
(iii)	Size of chamber, L*B*D (m)	
(iv)	Max, Average, and Min water levels (m)	
(v)	Head loss (m)	
(e)	Fine Screen Influent Channel & Chamber	
(i)	Size of channel, L*B*D (m)	
(ii)	No. and size of gated openings weir gates	
(iii)	Max, Average, and Min water levels (m)	
(f)	Grit Basin Distribution Channel	
	(i) Size of channel L*B*D (m)	

S. No.	Units	STP
	(ii) No. and size of gated openings and type of gates – Screen Effluent	
	(iii) No. and size of gated openings and weir gates – Grit Basin Influent	
	(iv) Max, Average, and Min water levels m)	
(g)	Grit Basins	
	(i) Particle size to be removed (mm)	
	(ii) Specific gravity	
	(iii) Efficiency of removal (%)	
	(iv) Size of grit basin influent structure (m)	
	(v) Grit Basins - Number - Capacity, each MLD - Size, each, L*B*D (m)	
	(vi) Surface overflow rate (m^3/m^2/day)	
	(vii) Max, Average, and Min water levels in grit chamber m)	
(h)	Grit Basin Effluent Channel	
	(i) Size of channel (m)	
	(ii) No. and size of gated openings and type of gates	
	(iii) Max, Average, and Min water levels (m)	
	(iv) Size of Bypass channel/pipe (m), Material of Construction	
(i)	Aeration Basin Influent Channel/Distribution Chamber	
	- Size of channel - No. of distribution branches - Size of each branch, L*B*D (m) - No. and size of gated openings and weir gates (m) - Size of Bypass channel/pipe (m), Material of Construction - Max, Average, and Min water levels (m)	
(j)	Aeration Basins	
	(i) - No. of basins - Length-to-width ratio for each basin	

S. No.	Units	STP
	(ii) Process info - Total volume (m^3) - Total HRT (Hrs) - Total SRT (days) - Anaerobic SRT (days) - Anoxic SRT (days) - Aerobic SRT (days) - Overall Length and Width for all basins (m) - Overall F/M ratio (Kg BOD removed/ Kg MLVSS/ day) - Mixed Liquor Recycle (MLR) ratio - MLR "From" and "To" locations - Return Activated Sludge (RAS) ratio - RAS "From" and "To" locations	
	(iii) Anaerobic Zones - No. of zones per basin - Volume per basin (m^3) - Total anaerobic volume (m^3) - Anaerobic volume as fraction of total volume - Side-Water Depth (SWD) (m) - Anaerobic MLSS (mg/l) - Anaerobic MLVSS (mg/l)	
	(iv) Anoxic Zones - No. of zones per basin - Volume per basin (m^3) - Total Anoxic volume (m^3) - Anoxic volume as fraction of total volume - Side-Water Depth (SWD) (m) - Anoxic MLSS (mg/l) - Anoxic MLVSS (mg/l)	
	(v) Aerobic Zones - No. of zones per basin - Volume per basin (m^3) - Total Aerobic volume (m^3) - Aerobic length-to-width ratio for each basin - Aerobic volume as fraction of total volume - Side-Water Depth (SWD) (m) - Aerobic MLSS (mg/l) - Aerobic MLVSS (mg/l)	

S. No.	Units	STP
	(vi) Hydraulic info - Aeration basin internal baffle weir elevations (m) - Max, Average, and Min water levels in all zones (m)	
(k)	Deleted	
(l)	Aeration Basin Effluent Channel (Not applicable to SBRs)	
	- Size of channel, L*B*D (m) No. and size of gated openings and weir gates (m)	
(m)	- Deleted	
(n)	Process Air Blower Building (i) Inside dimensions of blower room (Length x Width) (m) (ii) Inside dimensions of panel room (Length x Width) (m) (iii) Area allocated for loading / unloading (m^2) Height of Building (m)	
(o)	Chlorine Contact Tank Influent Channel - Size of channel - No. and size of gated openings and weir gates (m) - Size of bypass channel/pipe (m), Material of Construction	
(p)	Chlorine Contact Tank(s)	
	(i) Number of tanks	
	(ii) Volume of each tank (m^3)	
	(iii) Total hydraulic retention time (all tanks) at peak flow (min.)	
	(iv) Overall Length and Width of all tanks (m)	
	(v) No. of passes per tank	
	(vi) Pass width (m)	
	(vii) Max, Average, and Min water depth (m)	
	(viii) Total length of travel of liquid per tank (m)	
	(ix) Effective length-to-width ratio	
(q)	Chlorine Contact Tank Effluent Channel	

S. No.	Units	STP
	- Size of channel (m) - No. and size of gated openings and weirs or gates (m) - Length and size, invert level of final effluent pipe/conduit to disposal point (m)	
(r)	Chlorination Building (i) Inside dimensions of chlorinator room (m) (ii) Inside dimensions of chlorine tonner room (m) Area allocated for loading / unloading (m^2) (iii) Height of Building (m)	
(s)	Chemical Building (i) Inside dimensions of alum storage room (m) (ii) Inside dimensions of alum solution tank room (m) Area allocated for loading / unloading (m^2) (iii) Height of Building (m)	
(t)	Disc Cloth filter	
	- Type/Make	
	- No. Of Units	
	- Blower capacity	
	- Other details to be furnished	
(u)	Sludge Sump & Pumping Station	
	(i) Building inside dimensions, L*B*H (m)	
	(ii) All building slab elevations (m)	
	(iii) Dia. (mm) and length (m) of rising main	
(v)	Centrifuge	
	Make	
	Model	
	Type	
	Quantity (W+S)	
	Motor rating	
	Motor speed	
	Centrifuge Force	
	Solid Discharge Type	
	Impeller material	
	Shaft material	
	Others Details	
(w)	Sludge Thickener	
	Make	
	Model	
	Type	

S. No.	Units	STP
	Quantity	
	Capacity	
	Others Details	
	Area allocated for transformer yard (m^2)	
(ab)	Size of DG set room (m x m x m)	
(ac)	Size of Switch Gear room (m x m x m)	
(ad)	Area allocated for transformer yard (m^2)	
(ae)	No. and Size of MCC rooms (m x m x m)	
	Width and Height of entrance gate (m) and wicket gate (m) with arrangement for cow guard	
(af)	Size of security shed (m x m x m)	
(af)	Area allocated for green belt (m^2)	
(ag)	Area allocated for two wheeler and four wheeler parking (m^2)	
(ah)	Width and length of approach road to site (m)	
(ai)	Width and length of roads inside the plant (m)	
(aj)	Internal drainage, water supply, and waste water disposal	
	(i) Storm water drain provision (size, length in m)	
	(ii) Water Supply and Sewerage Provision (Yes/No) - Capacity and size of water storage tank (m^3) - Capacity and size of overhead tank (m^3) - Capacity and size of septic tank (if required) (m^3)	
	(iii) Nos. and size of Culverts, road crossing, etc.	
(ak)	Reclamation / Site Development – If Applicable	
	(i) Proposed area of Reclamation (m^2)	
	(ii) Top levels after Reclamation (m)	
	(iii) Average depth of filling (m)	
	(iv) Total quantity of earth required (m^3)	
	(v) Side slope of the filling	
	(vi) Slope protection measures	
	(vii) Proposed compaction equipment to be deployed (Type and No.)	
	(viii) Test apparatus to be provided in field soil laboratory	
	(ix) Proposed open channel dimension - Top width (m) - Bottom width (m) - Side slope - Longitudinal slope - Length (m)	
	(x) Bottom slope protection for open channel	

S. No.	Units	STP
	(xi) Proposed equipment (type and number) for excavation, handling, transporting	
	(xii) Borrow pit - Name of the Location (s) - Area (m^2) - Type of soil in general	
(al)	Miscellaneous	
	The Bidder shall list here details of any other / additional items required for a complete installation.	

***Note**: 1) Sizes of units shall mean Length x Width x Depth/Height as applicable and shall be expressed in "metres" unless otherwise stated.*

2) Bidder shall furnish details in above table and write "NIL" wherever not applicable to the respective plant depending upon the process.

TECHNICAL SCHEDULE IV

INSTRUMENTATION & CONTROL EQUIPMENT
(To be completed by the Tenderer)

4.1 STP at Dr Shivarama Karatha Layout , Bengaluru: Instrumentation, Control & Automation Equipments

S. No	Description	Unit	Particulars
4.1.1 (a)	**Flow Measuring System** Electro Magnetic Flow Meter (i) Make and Model (ii) Accuracy (iii) Principle of measurement (iv) Measuring Range		
4.1.2 (a) (b) (c)	**Blower system Instruments** Air Flow Measurement System (i) Make and Model (ii) Measuring Range (iii) Accuracy (iv) Principle of measurement		
	Air Pressure Measurement System (i) Make and Model (ii) Measuring Range (iii) Accuracy (iv) Principle of measurement		
	Air Temperature Measurement System (i) Make and Model (ii) Measuring Range (iii) Accuracy (iv) Principle of measurement		

S. No	Description	Unit	Particulars
4.1.3	**Level Measuring System**		
(a)	Ultrasonic Type (i) Make and Model (ii) Beam Angle (iii) Accuracy		
(b)	Capacitance Type (i) Make and Model (ii) Accuracy		
(c)	Level Switches (i) Make and Model (ii) Type (iii) Range (iv) Accuracy		
4.1.4	**Pressure Indicating Transmitter** (i) Make and Model (ii) Type (iii) Range (iv) Accuracy (v) Re-Transmission output		
4.1.5	**Pressure Gauges** (i) Make and Model (ii) Type (iii) Accuracy		
4.1.6	**Pressure Switches** (i) Make and Model (ii) Type (iii) Accuracy		
4.1.7	**Instrumentation Earthing** (i) Make and Model (ii) Type of Material		

S. No	Description	Unit	Particulars
4.1.8	**Temperature-Measuring System** (i) Make and Model (ii) Range (iii) Type (iv) Accuracy (v) Principle of Measurement		
4.1.9	**Temperature Scanner Indicator** (i) Make and Model (ii) Accuracy (iii) No. of Channels (iv) Number of alarm contacts per channel		
4.1.10	**Alarm Annunciators** (i) Make and Model (ii) No. of Windows (iii) Accuracy		
4.1.11	**Two & Three Position Selector Switches (Including Electrical Accessories Like :-P.B's , LED's, MCB's e.t.c)** (i) Make and Model		
4.1.12	**Panel Mounted Digital Indicators** (i) Make (ii) Model No (iii) Accuracy		
4.1.13	**Surge Protection Devices** (i) Surge Rating (ii) Make & Model		
4.1.14	**Junction Boxes & Field Enclosures** (i) Make (ii) Model		

S. No	Description	Unit	Particulars
4.1.15	**Weight Indicator cum Transmitter** (i) Make and Model (ii) Type (iii) Accuracy		
4.1.16	**DO Analyze**r (i) Make and Model (ii) Accuracy (iii) Principle of Measurement (iv) Cleaning Method		
4.1.17	**ORP Analyzer** (i) Make and Model (ii) Accuracy (iii) Principle of Measurement (iv) Cleaning Method		
4.1.18	**ResidualChlorine Measuring System/Chlorination Equipment** (i) Make and Model (ii) Accuracy (iii) Principle of Measurement (iv) Cleaning Method		
4.1.19	**PH Analyzer** (i) Make and Model (ii) Accuracy (iii) Principle of Measurement (iv) Cleaning Method		
4.1.20	**Hardness Analyzer** (i) Make and Model (ii) Accuracy		
	(iii) Principle of Measurement (iv) Cleaning Method		
4.1.21	**H2S Analyzer** (i) Make and Model		

S. No	Description	Unit	Particulars
	(ii) Accuracy (iii) Principle of Measurement Cleaning Method		
4.1.21 (a)	**Online influent & effluent Water sampling and analysis system** (i) Make and Model (ii) Measuring Range (iii) Accuracy (iv) Type (v) Nos.		
4.1.22	**Laboratory Instruments** (As per clause No 13.15 and 13.16) (i) Make and Model (ii) Principle of Measurement		
4.1.23 (a) (b)	**Programmable Logic Controller (Redundant Hot Standby) &PLC Programming software** Make , Model & Series		
	Number of Inputs(CPU , I/O & Communication Modules, Converters, Switches shall be of the same series) (i) Digital Inputs (ii) Model No		
	(iii) Digital output (iv) Model No		
	(v) Analog Inputs		
	(vi) Model No		
	(vii) Analog outputs (viii) Model No		
(c)	Memory		
(d)	**Redundant Power Supply Modules for PLC CPU** (i) Make (ii) Model No		

S. No	Description	Unit	Particulars
(e)	**CPU, Communication Modules, Industrial Ethernet Switches** (i)Make (ii) Model No		
(f)	**Portable Programming Unit (Laptop)**		
(g)	**Redundant RTU+ GSM/GPRS Communication modules along with Interface Panel for communication with MIS-2, SCADA center** (i) Type, Make & Model No. (ii)Country of Origin (iii) Dimension and Resolution		
	PLC Programming software (i) Software Details (ii)Make & Model		
(i)	**Interposing Relays with base terminal** (i) Make & Model		
4.1.24 (a)	**SCADA Software (Dual – Redundant configuration)** (i) Software Details (ii) Un-Limited Tags (iii)Limited Tags		
(b)	**Operator & Engineering work stations PC's:** a. CPU Configuration b. Model c. Monitor Configuration d. Make		
(c)	**Commercial grade server PC's** a. CPU Configuration b. Model c. Monitor Configuration d. Make		
4.1.25	**Historian Software** (i) Make (ii)Model No		
4.1.26	**Printers & Printer Server** (i) OFFLINE (ii) ONLINE		

S. No	Description	Unit	Particulars
4.1.27	**RIO Modules along with Panels** (i) Make (ii) Model No		
4.1.28	**SMPS for Automation System** (i) Make (ii) Model No		
4.1.29	**Control Panels with internal wiring and Local Control Panels** (i) Make and Model (ii) Pre-Fabricated		
4.1.30	**Instrumentation (Analog) & Control Cables and Power Cables, OFC, Trays, Glands & Lugs, cable conduits** (i) Make (ii) No of Cores (iii) Type (iv) Size (iv) Country of Origin		
4.1.31	**62" LCD Screen with accessories and Commercial Grade PC** (i) Make & Model (ii) Dimension(Size) (iii) Resolution		
4.1.32	**Private Automatic Branch Exchange (PABX) System & No. of Extensions with Telephone Instruments** (i) Make & Model		
	(ii) Number of Extension with PABX system (iii) Quantity		
4.1.33	**Redundant FOC equipment +cabling +Insulated Pipes on conduits** (i) Make (ii) Type (iii) Country of Origin		
4.1.34	**System console/SCADA furniture** (i) Make (ii) Type		
4.1.35	**Uninterruptable Power Supply** (i) Make and Model (ii) Capacity (iii) Redundancy (iv) No. of batteries (v) Rating		

S. No	Description	Unit	Particulars
4.1.36	**CCTV** (i) Make & Model (ii) Type (ii) Resolution (iii) Nos.		
4.1.37	**Online Influent & Effluent Monitoring Equipment** (i) Make & Model (ii) Type (iii) Nos.		

TECHNICAL SCHEDULE V
ELECTRICAL WORKS
(To be completed by the Tenderer)

5.1 High Voltage Metal Enclosed Switchboards

Sr. No.	Description	Unit	Technical Particulars
5.1.1	Make		
5.1.2	Type		
5.1.3	Applicable Standards		
5.1.4	Quantity	No.	
5.1.5	Dimensions	mm x mm x mm	
5.1.6	Switchgear cubicles and Bus bar ratings		
(a)	Rated voltage, phases and frequency		
(b)	System Neutral Earthing		
(c)	Maximum system voltage	kV	
(d)	One minute power frequency withstand voltage	kV (rms)	
(e)	12/50 □sec impulse withstand voltage	kV (peak)	
(f)	Short circuit withstand		
	(i) Short time (1 sec) at rated voltage	kA(rms)	
	(ii) Dynamic rating	kA (peak)	
(g)	Reference ambient temperature		
(h)	Maximum temperature of bus bars droppers connectors and contacts at continuous current rating under site reference ambient temperature		
(i)	Continuous current rating of bus bar	A	
(j)	Bus bar material		
(k)	Bus bar Insulation		
(l)	Cable entry		
(m)	Cable type for Incoming and Outgoing feeders		
5.1.7	**Switchgear constructional Requirement**		
(a)	Thickness of sheet steel Frame, Frame enclosures, doors, covers and partitions	mm	
(b)	Degree of protection		
(c)	Colour finish shade		

Sr. No.	Description		Unit	Technical Particulars
(d)	Earthing bus	i) Material		
		ii) Size	mm x mm	
(e)	Earthing conductor	i) Material		
		ii) Size	mm x mm	
5.1.8	**Breaker Particulars**			
(a)	Circuit breaker type			
(b)	Voltage, phases and frequency			
(c)	Rated operating duty			
(d)	Rated current at reference ambient temperature (i) Incoming breakers		A	
	(ii) Outgoing breakers		A	
(e)	Rated breaking capacity		kA (rms)	
(f)	Rated making current		kA (peak)	
(g)	Short time current withstand for 1 sec duration		kA (rms)	
(h)	Total break time			
(i)	Operating mechanism type (Normal)			
	Operating mechanism type (Emergency)			
(j)	Minimum no. of auxiliary contacts			
(k)	Withstand test voltage			
	(i) One minute power frequency		kV (rms)	
	(ii) 1.2/50 □ sec impulse		kV (peak)	
(l)	Auxiliary control voltage (i) For closing / tripping coil			
	(ii) For spring charging motor			
	(iii) For space heaters and lighting			
(m)	Anti pumping feature			
(n)	Latching requirement			
5.1.9	**Current Transformers**			
(a)	Type			
(b)	Class of insulation			

Sr. No.	Description	Unit	Technical Particulars
(c)	Rated current ratio and burden (i) Incomers and bus couplers		
	(ii) Outgoing feeders		
(d)	Accuracy class (i) Metering		
	(ii) Protection		
(e)	Short time 1 sec current rating	kA (rms)	
(f)	Dynamic rating	kA (peak)	
5.1.10	**Voltage Transformers**		
(a)	Type		
(b)	Rated Voltage (i) Primary	V	
	(ii) Secondary – S1	V	
(c)	Method of connection (i) Primary – P		
	(ii) Secondary – S1		
(d)	Application – S1		
(e)	Rated burden	VA	
(f)	Accuracy class		
(g)	Rated voltage factor (i) Continuous		
	(ii) Short time		
(h)	Insulation class		
5.1.11 (a)	**Meters** Make		
(b)	Accuracy Class		
	(i) Indicating Meters		
	(ii) Energy Meter		
5.1.12	**Protective Relays**		
	Type		
	Auxiliary supply		
5.1.13	Annunciations Provided for 11kV Metal enclosed Switch board		
A	At STP substation		
B	AT Air Blower Bldg		
C	At DG Switchgear at substation near DG room		

Sr. No.	Description	Unit	Technical Particulars
5.1.14	Whether Cubicle Components Provided as per Part 12 -Particular Electrical Requirement of Specification	Yes / No	
5.1.15	Auxiliary A.C. Supply Voltage & Frequency	V, Hz	
5.1.16	Whether all the above details attached for all Switchgear cubicles at locations mentioned as per 5.1.13	Yes /No	

5.2 Distribution Transformers

Sr. No.	Description	Unit	Technical Particulars
5.2.1	Manufacturer		
5.2.2 5	Full load rating	KVA	
5.2.3 5	Number of Phases	One/ Three	
5.2.4	Rated no-load voltage		
	a) HV	KV	
	b) LV	KV	
5.2.5 5	Type of Cooling		
5.2.6 5	Rated percentage impedance	%	
5.2.7	Winding connections		
	a) HV		
	b) LV		
	c) Vector group		
5.2.8	Tapping on winding		
	a) On load/off load tap		
	b) Total tapping range	%	
	c) Tapping steps		
	d) On HV/LV windings		
5.2.9	Maximum temperature rise of		
	a) Oil by thermometer	^{0} C	
	b) Windings by resistance method	^{0} C	
5.2.10	Load loss at rated current at 75^0C winding temperature (guaranteed, subject to + tolerance as per applicable standard)	KW	
5.2.11	No-load losses (core loss and dielectric loss) at 100% rated voltage and frequency, subject to + tolerance as per applicable standard	KW	

Sr. No.	Description	Unit	Technical Particulars
5.2.12	Magnetization current at rated voltage and frequency in percent of full load current	%	
5.2.13	Weight		
5.2.13.1	Windings	Kg	
5.2.13.2	Core	Kg	
5.2.13.3	Oil	Kg	
5.2.13.4	Tank, coolers & fittings	Kg	
5.2.13.5	Total (5.2.13.1 TO 5.2.13.4)	Kg	
5.2.14	Efficiency at 75^0C Full Load, U.P.F.	%	
5.2.15	Maximum Flux Density		
5.2.15.1	At rated voltage	Wb/m^2	
5.2.15.2	At 110% of rated voltage	Wb/m^2	
5.2.16	Drawing number of the general outline drawing enclosed with the bid, showing the transformer with all its fittings and accessories in plan, front and side elevations and other relevant details.		

5.3 FCMA Starter Panel

Sr. No.	Description	Unit	Technical Particulars
5.3.1	Quantity	Nos.	
5.3.2	FCMA Neutral Soft Start Panel and Busbar Rating		
(a)	Rated voltage phases and frequency		
(b)	Motor rating	kW	
(c)	System neutral earthing		
(d)	Maximum system voltage	kV	
(e)	One minute power frequency withstand voltage	kV (rms)	
(f)	1.2/50 micro sec. impulse withstand voltage	kV (peak)	
(g)	Short circuit withstand		
	(i) Short time (1 sec) at rated voltage	kA (rms)	
	(ii.) Dynamic rating	kA (peak)	
(h)	Reference ambient temperature	C	
(i)	Maximum temperature of busbars		

Sr. No.	Description		Unit	Technical Particulars
	droppers connectors & contacts at continuous current rating under site reference ambient temperature			
(j)	Method of connection			
5.3.3	**FCMA Neutral Soft Start Panel Particulars**			
(a)	Bus bars rating and material			
(b)	Bus bar insulation			
(c)	Cable entry			
5.3.4	**FCMA Neutral Soft Start Panel Constructional Requirement**			
(a)	Thickness of sheet steel			
	(i) Frame, Frame enclosures, doors, covers and partition		mm	
(b)	Degree of protection			
(c)	Colour finish shade			
(d)	Earthing bus	Material		
		Size	mm x mm	
(e)	Earthing conductor	Material		
		Size	mm x mm	
(f)	Type of cooling for winding		-	
5.3.5	**Auxiliary Supply**			
(a)	Control			
(b)	Space heater & lighting			
5.3.6	**Current Transformer**			
(a)	Type			
(b)	System voltage & freq.			
(c)	Class of insulation			
(d)	Rated current ratio and burden			
(e)	Accuracy class Metering Protection			

Sr. No.	Description	Unit	Technical Particulars
(f)	Short time 1 sec. Current rating & dynamic rating	kA (rms) kA (peak)	
5.3.7 (a)	Differential Relay No. of poles		
(b)	Setting range % rated current		
(c)	No. of contacts		
(d)	Reset type		
(e)	Flag indicator		
(f)	Coil rating	A	
5.3.8	Following Requirement shall be provided in panel		
(a)	Starting interlock with incomer 11 kV vacuum contactor		
(b)	Trip circuit		
(c)	Running mode signal		

5.4 11 kV Capacitor Bank with Panel

Sr. No.	Description	Unit	Technical Particulars
5.4.1	Quantity	Nos.	
5.4.2 (a)	**11 kV Capacitor Bank Panel** Rated voltage, phases and frequency		
(a)	System neutral earthing		
(b)	Maximum system voltage	kV	
(c)	One minute power Frequency withstand voltage	kV (rms)	
(d)	1.2/50 micro sec. impulse withstand voltage	kV (peak)	
(e)	Short circuit withstand (i) Short time (1 sec) at rated voltage	kA (rms)	
	(ii) Dynamic rating	kA (peak)	
g)	Reference ambient temperature	□ C	
h)	Maximum temperature of busbars droppers connectors and		

Sr. No.	Description		Unit	Technical Particulars
5.4.3	**Capacitor Banks**			
(a)	Application			
(b)	Quantity		Nos.	
(c)	Rated capacity			
(d)	Rated voltage		kV	
(e)	Frequency		Hz	
(f)	No. of phases			
(g)	Cable gland required			
(h)	Size of cable		mm^2	
(i)	Capacitor bank			
(j)	Type of capacitor bank connection			
(k)	If star connected, mode of neutral connection			
5.4.4	**Capacitor Bank Panel Particulars**			
(a)	Bus bar size & material			
(b)	Bus bar encapsulation			
(c)	Cable entry			
5.4.5	**Capacitor Bank Panel constructional requirement**			
(a)	Thickness of sheet steel			
	(i) Frame, Frame enclosure, doors, covers and partition		mm	
(b)	Degree of protection			
(c)	Colour finish shade			
(d)	Earthing bus	Material		
		Size	mm xmm	
(e)	Earthing Conductor	Material		GS
		Size	mmxmm	50 x 10 (*)

Sr. No.	Description	Unit	Technical Particulars
5.4.6	**Load Break Switches**		
(a)	Application		
(b)	Type		
(c)	Voltage frequency & No of phase		
(d)	Rated current at reference Ambient Temp.	A	
(e)	Rated making current	kA (peak)	
(f)	Withstand currents		
	(i) 1 Sec. Current	kA (rms)	
	(ii) Momentary	kA (Peak)	
(g)	Withstand Test Voltage		
	(i) One minute power freq.	kV (rms)	
	(ii) 1.2/50 micro Impulse	kV (peak)	
(h)	Type of switching		
5.4.7	**Current Transformer core Balance type**		
(a)	Type		
(b)	System voltage and freq.		
(c)	Class of insulation		
(d)	Rated current ratio and burden		
(e)	Accuracy class protection		
(f)	Short time		
	(i) 1 second current rating	kA(rms)	
	(ii) Dynamic rating	kA(Peak)	
5.4.8	**H.V. Fuses**		
(a)	Rated current	A	
(b)	Voltage class	kV	
(c)	Symmetrical Breaking capacity	kA (rms)	

5.5 Metal Enclosed Switchgears PCC/MCC

Sr. No	Description		Unit	Technical Particulars
5.5.1	**Make**			
5.5.2	**415 V Switchgear And Busbar Ratings**			
(a)	Rated voltage phase and frequency			
(b)	System Neutral Earthing			
(c)	Maximum system voltage		V	
(d)	One minute power frequency voltage			
	i) Power circuits		V	
	ii) Control circuits		V	
	iii) Aux. Circuits connected to Sec of CTS		V	
(e)	Continuous current rating of Busbars under site reference Ambient Temperature and type & material		Rating Material	
(f)	Busbar insulation			
(g)	Reference Ambient Temperature		◦ C	
(h)	Maximum Temperature of Busbars, Droppers and Contacts at Continuous current rating under site ambient temperature		◦ C	
(i)	Short Circuit current withstand for Busbars and droppers (i) Short time 1 sec		kA (RMS)	
	(ii) Dynamic Rating		kA (Peak)	
5.5.3	**Switchgear Constructional Requirement**			
(a)	Type of Construction			
(b)	Thickness of sheet steel (i) Frame, Frame enclosures, doors, covers and partitions		mm	
(c)	Degree of protection			
(d)	Colour finish shade			
(e)	Earthing bus	Material		
		Size	mm x mm	
	Earthing conductor	Material		
		Size	mm x mm	
(g)	Minimum clearances in air of live parts (i) Phase to Phase		mm	

Sr. No	Description	Unit	Technical Particulars
	(ii) Phase to Earth	mm	
(h)	Cable entry to cubicles		
5.5.4	**Change over Switch**		
(a)	Applicable Standards		
(b)	Quantity	No.	
(c)	Rating	A	
(d)	Short circuit current capacity for 1 sec	kA (rms)	
(e)	Provision of Safety Key Lock	Yes /No	
(f)	Auxiliary Contacts		
5.5.5	**Instrumentation Transformers**		
(a)	Current transformer		
	(i) Ratio		
	(ii) Burden	VA	
	(iii) Accuracy Class		
(b)	Voltage transformer		
	(i) Ratio		
	(ii) Burden	VA	
	(iii) Accuracy Class		
5.5.6	Whether all the above details attached for all Switchgear cubicles at Process Air Blower Building	Yes /No	

5.6 415 V Power Capacitor and Control Panel

Sr. No	Description	Unit	Technical Particulars
5.6.1	**General**		
(a)	Make		
(b)	Rated Capacity	KVAR	
(c)	Rated voltage	V	
(d)	Rated frequency and phases		
(e)	Ambient temperature	° C	
(f)	Cable gland required		
(g)	Type of cable		
(h)	Size of cable		
(i)	Cable entry		

Sr. No	Description		Unit	Technical Particulars
5.6.2	**Constructional Requirement**			
(a)	Thickness of sheet steel i) Frame, Frame enclosures, doors covers and partition		Mm	
(b)	Degree of protection			
(c)	Colour finish shade			
(d)	Earthing bus	Material		
		Size	mm x mm	
(e)	Earthing conductor	Material		
		Size	mm x mm	
5.6.3	**Design Requirement**			
(a)	Insulation level		kV (rms)	
(b)	Capacitor bank connection			
(c)	Short circuit withstand for busbars i) Short time (1 sec)		kA (rms)	
	ii) Dynamic		kA (peak)	
(d)	Type of switching			
(e)	Switching steps			
(f)	Switch and Rating of contactor			
(g)	Incomer MCCB current rating			
(h)	O/L capacity of capacitors			
(i)	O/V capacity of capacitors			
(j)	Protections			

5.7 Diesel Standby Generator Sets

Sr. No.	Description	Unit	Technical Particulars
5. 7.1	**General**		
(a)	Set Manufacturer		
(b)	Quantity & Type		
(c)	Applicable Standard		
(d)	Rating		
(e)	Provision of AMF Control Panel	Yes/ No	
(f)	Provision of Synchronising Panel	Yes/ No	
5. 7.2	**Alternator**		
(a)	Manufacturer		

Sr. No.	Description	Unit	Technical Particulars
(b)	Type		
(c)	Applicable Standard		
(d)	Rating	KVA	
(e)	Voltage	V	
(f)	Number of phases		
(g)	Frequency	Hz	
(h)	Power Factor		
(i)	Rated Current	A	
(j)	Overload Capacity		
(k)	Class of Insulation		
(l)	Degree of protection		
(m)	Winding Connection		
(n)	Short circuit current		
(o)	Type of rotor bearings		
(q)	Provision of temperature sensors in stator windings		
(r)	Exciter		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(s)	AVR		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(t)	Voltage regulation		
(u)	Outgoing Cable		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	Size		
5. 7.3	**Diesel Engine**		
(a)	Manufacturer		
(b)	Type		
(c)	Applicable Standard		
(d)	Rating	HP	
(e)	Speed	RPM	
(f)	Number of Cylinders		
(g)	Number of Strokes		
(h)	Type of Starting		

Sr. No.	Description	Unit	Technical Particulars
(i)	Duty		
(j)	Overload Capacity		
(k)	Radiator		
	(i) Make		
	(ii) Type		
	(iii) Fan power		
	(iv) Cooling air flow		
(l)	Exhaust system		
	(i) Type of Silencer		
	(ii) Exhaust temperature gauge range		
(m)	Governor		
	(i) Make		
	(ii) Type		
	(iii) Applicable Standard		
	(iv) Class of governor		
(n)	Cooling Water System		
	(i) Water temperature		
	(ii) Water Pressure		
	(iii) System Capacity		
	(iv) Provision of High water temperature and low water level		
(o)	Lubricating oil system		
(i)	Grade of Oil		
(ii)	Oil Pressure		
(iii)	Oil temperature		
(iv)	Sump Capacity		
(v)	Oil Consumption per 100 hours		
(vi)	Recommended time period of Oil Change		
(p)	Fuel		
(i)	Fuel Specification		
(ii)	Fuel Consumption at rated Capacity		
(q)	Day oil tank		
(i)	Capacity	Litres	
(ii)	Provision of Level Gauge		
(r)	Bulk Storage tank		
(i)	Location		
(ii)	Type		

Sr. No.	Description	Unit	Technical Particulars
(iii)	Capacity		
5.7.4	**AMF Control Panel**		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	Constructional Features		
(a)	Thickness of sheet steel Frame, Frame enclosures, doors covers and partition	mm	
(b)	Colour finish shade - Interior		
(c)	Colour finish shade - Exterior		
(d)	Degree of Protection		
(v)	AMF Features Provided as per Technical Specification	Yes/No	
5.7.5	Protections, Alarm, Indications & Control whether provided as per Specification	Yes/No	
5.7.6	Synchronising Panel		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	Constructional Features		
(a)	Thickness of sheet steel Frame, Frame enclosures, doors covers and partition	mm	
(b)	Colour finish shade - Interior		
(c)	Colour finish shade - Exterior		
(d)	Degree of Protection		
(v)	Synchroscope		
(a)	Make		
(b)	Type		
(c)	Applicable Standard		
5.7.7	Acoustic Enclosure		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	Constructional Features		

Sr. No.	Description	Unit	Technical Particulars
(a)	Thickness of sheet steel Frame, Frame enclosures, doors covers.	mm	
(b)	Degree of Protection		
(c)	Acoustic material		
(iv)	Sound level at 1m distance		
(v)	Whether certified to meet emission norms	Yes/No	
5.7.8	Battery		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	Voltage		
(v)	Capacity at 10 hours rate		
(vi)	Number of successive starting permissible		
5.7.9	Battery Charger		
(i)	Make		
(ii)	Type		
(iii)	Applicable Standard		
(iv)	AC Input to Charger		
(v)	DC Output of Charger		

5.8 Variable Frequency Drives

Sr. No.	Description	Unit	Technical Particulars
5.8.1	**General**		
(a)	Make		
(b)	Type		
(c)	Applicable Standard		
(d)	Drive Application		
(e)	Quantity	Nos.	
(f)	Type of converters		
(g)	Inverter capacity at specified pf		
(h)	Rated Current		
(i)	Load power factor		
(j)	Max. continuous current		

Sr. No.	Description	Unit	Technical Particulars
(k)	Rated voltage with number of phases		
(m)	Rated frequency		
(n)	Converter Bridge		
(o)	Single Quadrant/Two quadrant/ Four Quadrant		
5.8.2	Control Characteristics		
(a)	Speed Control		
(b)	Rated speed		
(c)	Speed ratio		
(d)	Constant torque/constant power		
(e)	Speed accuracy		
(f)	Closed loop/open loop		
(g)	Accel./ Deccel. time		
(h)	Possibility of Remote Operation	Yes / No	
5.8.3	Overall Harmonic Limitation	%	
5.8.4	Braking		
(a)	Type of braking		
(b)	Braking Torque		
5.8.5	Miscellaneous		
(a)	Soft-start	Yes/No	
(b)	Flying restart	Yes/No	
(c)	Auto restart	Yes/No	
(d)	Kinetic Buffering	Yes/No	
5.8.6	Confirm whether following minimum Indications on Drive Panel are Provided	Yes/No	
(a)	Motor running		
(b)	Motor stopped / trip		
(c)	AC mains 'ON'		
(d)	System Ready to start		
(e)	VFD system fault		
5.8.7	Confirm whether Digital Display of following Minimum parameters on the Drive Panels:-	Yes/No	
(a)	Input AC Voltage		
(b)	Input AC Frequency		
(c)	Input AC Current		

Sr. No.	Description	Unit	Technical Particulars
(d)	Output Voltage		
(e)	Output Current VFD/Bypass		
(f)	Output Frequency		
(g)	Motor speed		
(h)	Whether Necessary transducers provided for indicating motor speed & current in PLC/DCS.	Yes/No	

5.9 Battery

Sr. No.	Description	Unit	Technical Particulars
5.9.1	Make		
5.9.2	Type of battery		
5.9.3	Applicable Standards		
5.9.4	Number of battery banks required		
5.9.5	Ambient conditions		
5.9.6	D.C. system voltage	V	
5.9.7	Ampere hour capacity of battery at 27 Deg. C at 5 hour rate to give final cell voltage of 1.16 volts/cell	Ah	
5.9.8	Momentary load/duration	A	
5.9.9	Emergency load/duration	A	
5.9.10	Continuous load/duration	A	
5.9.11	Nominal voltage	V	
5.9.12	Cell voltage - initial/final	V	
5.9.13	Number of cells per bank required to give rated voltage	Nos.	
5.9.14 .	Number of spare cells per bank	Nos.	
5.9.15	Overall dimensions		
a	Each Cell (L x W x H)	mm x mm x mm	
b	Complete battery in the rack	mm x mm x mm	
5.9.16	Mounting arrangement		
5.9.17	Charging method		

5.10 Battery Charger

Sr. No.	Description		Unit	Technical Particulars
5.10.1	**General**			
(a)	Make			
(b)	Applicable Standards			
(c)	Number required (i) Battery charger		Nos	
(d)	Rated Output voltage (DC)		V	
(e)	Rated Output		kW	
(f)	DC System Earthing			
(g)	Voltage regulation from no load to rated load		%	
(h)	Ambient Design Temperature		Deg. C	
(i)	Busbar material & size		-	
(j)	Overall dimensions		mm x mm x mm	
5.10.2	**Battery Details**			
(a)	Float/Trickle charging current of battery		mA	
(b)	Boost Charging Current of Battery (Maximum)		A	
(c)	Boost Charging Voltage of Battery (maximum)		V	
(d)	Maximum Time for Boost charging of Battery		hr	
(e)	Battery capacity & no. of cells		Ah	
			Nos.	
5.10.3	**AC System Data**			
(a)	Supply	Voltage	V	
		Phase		
(b)	(i) Variation in supply Voltage		%	
	(ii) Variation in supply frequency		%	
(c)	Short Circuit level		kA	
(d)	Type of earthing			
5.10.4	**Performance**			
(a)	DC voltage setting adjustment for float charger			
(b)	Voltage stabilisation for constant			

Sr. No.	Description		Unit	Technical Particulars
	voltage regulator			
(c)	Maximum permissible variation in DC voltage (no load to full load)			
(d)	D.C. voltage setting adjustment for boost charging			
(e)	D.C. current adjustment for boost Charging			
(f)	Current stabilisation for constant current regulator for boost charger			
(g)	Minimum permissible power factor to rated continuous load			
(h)	Permissible ripple content at rated continuous load			
(i)	Relay for auto changeover from Float to boost mode to be provided (in case of float-cum-boost charger)			
5.10.5	**Constructional Features**			
(a)	Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition		mm	
(b)	Degree of protection			
(c)	Colour finish shade			
(d)	Earthing bus	Material		
		Size	mm x mm	
(e)	Earthing conductor	Material		
		Size	mm x mm	
(f)	Cable entry			
(g)	Cable Sizes (i) Battery		sq.mm	
	(ii) DC output		sq.mm	
	(iii) AC input		sq.mm	

5.11 DC Distribution Board

Sr. No.	Description	Unit	Technical Particulars
5.11.1.	**General**		
(a)	Make		
(b)	Applicable standards		
(c)	DC System voltage (Nominal)	V	

Sr. No.	Description		Unit	Technical Particulars
5.11.2	DC System Earthing			
5.11.3	Ambient Design Temperature		Deg. C	
5.11.4	Bus bar material , rating and size			
5.11.5	**DC Bus Load**			
(a)	Total continuous DC load		A	
(b)	Short time loads (Additional to continuous loads)			
	(i) DC lights/Facia lamps		A	
	(ii) Starting current and duration of Largest Connected DC Motor		A	
			Secs	
5.11.6	**Constructional Features**			
(a)	Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition		mm	
(b)	Degree of protection			
(c)	Colour finish shade			
(d)	Earthing bus	Material		
		Size	mm x mm	
(e)	Earthing conductor	Material		
		Size	mm x mm	
(f)	Cable entry			
(g)	Cable Sizes (i) DC Input from Battery		sq.mm	
	(ii) DC output to Load		sq.mm	

5.12 Non Segregated Bus Duct

Sr. No.	Description	Unit	Technical Particulars
5.12.1	Type of Bus Duct		
5.12.2	Type of Cooling		
5.12.3	Installation		
5.12.4	Nominal Service Voltage	V	
5.12.5	Rated Voltage Class	V	
5.12.6	Continuous Current Rating of Bus Ducts under Site Conditions	A	

Sr. No.	Description	Unit	Technical Particulars
5.12.7	One minute Power Frequency Withstand Voltage	V	
5.12.8	Momentary Current Rating	kA	
5.12.9	Short Time Current Rating for one second - kA (RMS)	kA	
5.12.10	Maximum Temperature (Hot Spot) of Busbars at Rated Current - °C		
5.12.11	Maximum Temperature (Hot Spot) of Enclosure at Rated Current °C		
5.12.12	Busbar Material		
5.12.13	Busbar Section		
5.12.14	Bus Enclosure Material		
5.12.15	Shape of Enclosure		
5.12.16	Phase Clearance (Minimum) Phase to Phase Phase to Earth	 mm mm	
5.12.17	Type of Joints between Adjacent Sections of Bus Conductor Welded/Bolted		

5.13 Cable

Sr. No.	Description	Unit	Technical Particulars
5.13.1	**11kV (UE) XLPE Insulated Power Cables**		
(a)	Make		
(b)	Type		
(c)	Applicable Standards		
(d)	Cable size selection whether done as per Specification	Yes /No	
(e)	Continuous current rating with cable laid in air/ground under specified ambient temperature	A	
(f)	Conductor material		
(g)	Conductor screening		
(h)	Insulation		
(i)	Screening on Insulation		
(j)	Identification of codes		
(k)	Inner sheath		
(l)	Filler material		
(m)	Armouring		
(n)	Outer sheath		
(o)	Overall diameter of the cable	mm	
(p)	Recommended minimum bending radius	mm	
(q)	Standard length of cable on each drum	mts	

Sr. No.	Description	Unit	Technical Particulars
5.13.2	**1100 V Grade XLPE Insulated Power Cables**		
(a)	Make		
(b)	Type		
(c)	Applicable Standards		
(d)	Cable size selection whether done as per Specification	Yes /No	
(e)	Conductor material		
(f)	Insulation		
(g)	Inner sheath		
(h)	Armouring		
(i)	Outer sheath		
(j)	Overall diameter of cable		
(k)	Recommended minimum bending radius	mm	
(l)	Standard length of cable on each drum	mts	
5.13.3	**1100 V Grade PVC Insulated Power Cables**		
(a)	Make		
(b)	Type		
(c)	Applicable Standards		
(d)	Cable size selection whether done as per Specification	Yes /No	
(e)	Recommended minimum bending radius	mm	
(f)	Standard length of cable on each drum	mts	
5.13.4	**650/1100 V Grade PVC Insulated Control Cables**		
(a)	Make		
(b)	Type		
(c)	Applicable Standards		
(d)	Rated voltage		
(e)	Cable size selection		
(f)	Conductor material		
(g)	Insulation		
(h)	Inner sheath		
(i)	Armouring		
(j)	Outer sheath		
(k)	Standard length of cable on each drum	mts	

5.14 Lighting Fixtures and Accessories

Sr. No.	Description	Unit	Technical Particulars
5.14.1	**General**		
(a)	Illumination levels at various premises whether considered as per Specification	Yes /No	
(d)	Normal supply voltage, phase and	AC	

Sr. No.	Description	Unit	Technical Particulars
	frequency	DC	
(e)	Variation in supply:		
	(i) Voltage (AC & DC)	%	
	(ii) Frequency	%	
	(iii) Combined voltage & frequency	%	
(f)	Design ambient air temperature	^0C	
5.14.2	Luminaire terminal suitable for		
(a)	Indoor area		
	(i) Conductor material		
	(ii) Cable size	Cores x mm^2	
(b)	Outdoor area		
	(i) Conductor material		
	(ii) Cable size	Cores x mm^2	
5.14.3	Luminaire earthing terminal suitable for		
	(i) Conductor material		
	(ii) Conductor size	SWG	
5.14.4	Luminaires		
(i)	Fluorescent Luminaires		
(a)	Make		
(b)	Type		
(c)	Rating		
(ii)	HPSV Luminaires		
(a)	Make		
(b)	Type		
(c)	Rating		
(iii)	Flood Light Luminaires		
(a)	Make		
(b)	Type		
(c)	Rating		

5.15 Lighting System and Equipment

Sr. No.	Description	Unit	Technical Particulars
5.15.1	**System Particular**		
(a)	**Voltage**		
	(i) 3 Phase, 4 wire 50 Hz system		
	• Rated	V	
	• Maximum	V	
	• One minute withstand voltage		
	(ii) D.C. system		
	• Rated	V	
(b)	System short-circuit level		
	(i) At 415 V, A.C.	kA (RMS)	
	(ii) At 110 V.D.C.	kA (D.C.)	
(c)	Reference ambient temperature	^{0} C	
5.15.2	**Distribution Board/Panels**		
(a)	Main, floor mounted distribution boards		
(i)	Main Lighting distribution board(A.C.)		
	• Make		
	• Type		
	• Degree of protection		
	• Bus bar material		
	• Bus bar current rating	A	
	• Short circuit current rating	kA	
	• Details of Incoming and Outgoing feeders		
	• Cable entry		
	• Location		
(ii)	Emergency lighting panel (D.C.)		
	• Make		
	• Type		
	• Degree of protection		
	• Bus bar material		
	• Bus bar current rating	A	
	• Short circuit current rating	kA	
	• Details of Incoming and Outgoing feeders		
	• Cable entry		
	• Location		
(iii)	Single phase Lighting DBs (SLDBs), Three Phase lighting DBs (TLDBs) / Wall/ Structure mounting		
	SLDB/TLDB for indoor area		
	• Make		
	• Type		
	• Details of Incoming and Outgoing feeders		

Sr. No.	Description	Unit	Technical Particulars
	• Degree of Protection		
(iv)	SLDB/TLDB for outdoor area		
	• Make		
	• Type		
	• Details of Incoming and Outgoing feeders		
	• Degree of Protection		
(v)	Paint Finish		
	(i) Colour shade:		
5.15.3 (a)	**Street Light Poles And Flood Light Poles** Street Light Pole		
	Type		
	Total Height:	MTRS	
	Quantity:	Nos.	
(b)	Floodlight Light Pole		
	Type		
	Total height :	MTRS	
	Quantity:	Nos.	
	No. Of floodlights to be fixed per pole	No.	

5.16 Earthing and Lightning Protection System

Sr. No.	Description	Technical Particulars		
		Size	Material	No. of Leads & Quantity
5.16.1 (a)	**Main Earthing Grid** Buried in earth			
(b)	Buried in floor slabs in buildings			
5.16.2	**Conductor Leads To Equipment** (above ground)			
(a)	Transformers			
(i)	Transformer neutral to bottom of tank			
(ii)	From bottom of tank to earth grid			
(iii)	Transformer tanks and radiator bank			
(b)	Diesel Generator Set			
(i)	DG Set neutral earthing			
(ii)	DG Set body earthing			
(c)	Fence posts and gates (Flex. braid)			
5.16.3	11kV Metal Enclosed Switchboard, 415V switchgear/ MCC.			
5.16.4	Motors			
(a)	415V Motors above 10 kW			
(b)	415V Motors up to 10 kW			
(c)	Fractional horse power motors			
5.16.5	**Other Items**			
(a)	Capacitor panel, Battery charger panel,			

Sr. No.	Description	Technical Particulars		
		Size	**Material**	**No. of Leads & Quantity**
	DC distribution board , Main lighting D.B, Control panels and sub-lighting distribution boards etc			
(b)	Hand Rails			
(c)	Cable trays			
(d)	Tanks			
(e)	Junction boxes			
(f)	Lighting fixtures, receptacles, lighting conduits			
(g)	Push button stations, limit switches			
5.16.6	**Crane rail**			
5.16.7	Street lighting, flood lighting poles and junctions boxes			
5.16.8	Metallic noncurrent carrying structures			
5.16.9	**Lightning Conductors**			
(a)	Lightning protection down comers for building			
(b)	Lightning protection horizontal roof conductor for building			
5.16.10	**Electrodes**			
(a)	Pipe electrode			

TECHNICAL SCHEDULE VI

SEWAGE TREATMENT PLANT OPERATING DETAILS

(To be completed by the Tenderer)

Sl. No	Item	Unit	Description
Electrical Usage			
Total Energy Consumption of the Plant for a day and month (*)		kWh/ day	
		kWh/Month	
* The Tenderer shall substantiate Total Energy Consumption figure of the Plant by submission of Detailed Daily and Monthly Specific Energy Consumption Calculation The following factors / assumptions shall be considered by the Tenderer in arriving at the Monthly Energy Consumption figures. (i) The Sewage Treatment Plant is operated at average flow(i.e) **25 MLD** for 24 hours in a day for the entire month. (ii) The Tenderer shall consider 24 hours operation for Continuous Service Equipments as listed in Section 7, Part 11-Particular Mechanical Requirements of the Bid document. (iii) The Energy Consumption calculation shall be derived without considering Energy Savings due to Introduction of VFD. (iv)The Tenderer shall consider appropriate efficiency factor in arriving at Working load of each equipment. (v) No of days in month shall be based on 365days / 12months			
Chemical Usage			
Chlorine:			
1.	Chlorine dosage at peak hydraulic (Peak hour) flow	mg/L	
2.	Average Chlorine Dose	mg/l	
Polymer:			
1.	Quantity of Sludge to be dewatered	Tons/day	
2.	Average dewatering polymer dose	kg/ton of dry solids	
Alum:			
1.	Average alum dose	mg/L	

Sewage Treatment Plant Operating Details – Quantities of Chemical Consumptions
(will be considered for financial bid Evaluation)

Sl. No.	Name of Chemical	Average Quantity (Tonnes/Year)
1	Alum	
2	Chlorine	
3	Polyelectrolyte	
4	Any other Chemicals	

TECHNICAL SCHEDULE VII

SCHEDULE OF SUB CONTRACTORS

(To be completed by the Tenderer)

Name of the Tenderer

The Tenderer shall enter in this Schedule a list of the sub-components and approximate value (in terms of percentage of Cost of Construction Works) of the construction work for which he proposes to use subcontractors, together with the names and addresses of the proposed subcontractors. The Tenderer shall also enter a statement of similar works previously executed by the proposed subcontractors, including description, location and value of work, year completed, and name and address of the Employer/ Employer's Representative. The Contractor shall provide evidence from the Employer/ Engineer that the subcontractor has previous successful experience in carrying out the works of a similar nature as the Contract. Notwithstanding such information, the Bidder, if awarded the Contract, shall remain entirely and solely responsible for the satisfactory completion of the Works.

Elements of Work	**Approximate Value of Work (INR)**	**Name and Address of Sub Contractor**	**Statement of Similar Works Previously Executed (within last 5 years)**

TECHNICAL SCHEDULE VIII

QUALITY ASSURANCE & QUALITY CONTROL PLAN
(To be completed by the Tenderer)

The Bidder shall provide copies of the company's standard rules and regulations regarding Quality Assurance and Quality Control procedures for works in general and works of a similar nature.

The Bidder shall provide its proposed Quality Assurance and Quality Control Plan in detail so as to demonstrate the procedures and tests that will be used to ensure that the quality concerns and requirements as set forth in Volume 2 Employer's Requirements; Section 7 - Technical Specifications, Section 3.24 of Part 3- General Requirements are satisfactorily met.

The proposed plan will describe but not limited to:

- the type, frequency and procedure of tests to be done on site(s);
- type, frequency and procedure of tests to be done in pipe manufacturing units at site(s), if applicable;
- type, frequency and procedure of tests to be done at manufacturers' locations outside the site(s);
- all parameters to be measured in these tests; permissible limits of such parameters; details of laboratories to be established at site(s); details of testing equipments & machines and their calibration schedules
- details of the Bidder's internal systems for assuring quality control at the manufacturers' works outside the site(s);
- details of qualifications and experience of the Quality Control professionals to be deployed for the entire project; and
- the systems of Quality Audit to be instituted for systematic and professional management as well as adherence with the highest standards of quality of all construction works.
- All the tests of samples taken from the site(s) are proposed to be done through recognized test houses of international standards and number of samples and frequency of sampling of materials brought to the site(s) and the products manufactured at site(s) shall be as per I.S. Specifications. All such samples shall be taken in the presence of Employer's authorized representatives.

The Bidder shall provide separate descriptions of its proposed QA/QC plan during the construction phase and the subsequent operations and maintenance phase.

This will be an initial QA/QC plan which will address to basic requirements of Quality control and Quality assurance of the works.

TECHNICAL SCHEDULE IX

ENVIRONMENTAL MANAGEMENT PLAN

(To be completed by the Tenderer)

Name of the Tenderer

The Bidder shall provide his proposed Environmental Management Plan in detail so as to demonstrate the procedures that will be used to ensure that the environmental concerns and requirements as set forth in Volume 2 Employer's Requirements; Section 7 - Technical Specifications, Section 3.25 of Part 3- General Requirements are satisfactorily met.

The Environment Management Plan shall identify the potential environmental impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach that will be adopted in mitigating these environmental impacts to ensure that the residual impacts are minor and confined to a short period.

While preparing the proposed Environmental Management Plan the Bidder shall consider but not be limited to the following:

- The Bidder shall pay attention to the methods of materials delivery, storage, usage and disposal; equipment usage; and site activities to ensure they have minimal impact on the environment,
- The Bidder shall propose only environmentally safe products and practices in performing his works, and
- The Bidder shall comply with all of the statutes regarding environmental effects.

The Bidder shall provide separate descriptions of its proposals for minimizing any adverse environmental impacts/effects during the construction phase and the subsequent operations and maintenance phase.

This will be an initial Environmental Management Plan (EMP) which will address all moderate and significant negative impacts of the construction and operation and maintenance activities to be performed in the contract.

Note: Contractor shall coordinate with KSPCB, KSEPA, LDA Departments and obtain applicable consents certificates necessary for construction and operation of the facility.

Contractor shall carryout Environment audit of the plant site periodically, positive and negative findings shall be reviewed and appropriate action shall be taken to rectify the deficiencies as per direction of Bangalore Development Authority (BDA). The reasons for the cause and action taken shall be highlighted in the progress report .

TECHNICAL SCHEDULE X

SAFETY PLAN
(To be completed by the Tenderer)

Name of the Tenderer

The Tenderer shall provide his proposed Safety Plan in detail so as to demonstrate compliance with the requirements set forth in Volume 2 Employer's Requirements; Section 7 - Technical Specifications, Section 3.26 of Part 3- General Requirements are satisfactorily met.

The Safety Plan shall include a policy statement signed by the CEO or equivalent authority of the Organization declaring that Safety and loss prevention shall be given the highest practicable priority in all aspects of the Contract.

The Tenderer shall describe his proposed Safety Plan which shall be developed to ensure zero fatal accidents and zero hazardous incidents/occurrences in all construction works, including descriptions of the company's standard policies and procedures regarding its site organization and procedures implementations, methods and frequency of conducting safety audits/inspection at the Site(s), record keeping and reporting includes compliance reports and monthly reporting, timely corrective action implementation for the issues, supervising and monitoring to sustain the established safety management system, conducting safety review meetings, providing safety training for its personnel as required for all major critical activities of the sites, issue and mandatory use of safety equipment and penalties for non compliance to be adopted within contractor organizations, keeping the plant and equipments well maintained and details of the qualifications and experience of the Bidder's proposed Accident Prevention Officer(s) to be deployed at the Site(s).

The Tenderer shall provide separate descriptions of its proposed Safety Plan during the construction phase and the subsequent operations and maintenance phase.

This will be an initial Safety Plan which will address to the Health and Safety of the all persons entitled to be at Site(s) including the Employer's personnel.

TECHNICAL SCHEDULE XI

FUNCTIONAL GUARANTEES OF THE PLANT
(To be completed by the Tenderer)

1 General

This document sets out the functional guarantees required to be provided by the Tenderer for assessing the performance of the Works. These guarantees shall be used by the Employer to evaluate Bidder's satisfactory performance during the Tests after Completion, and also throughout the Operation and Maintenance Period.

The Bidder shall complete the following sections and provide values for the electrical energy usage for the Works covered under the contract, based on the raw sewage flows and characteristics and effluent and sludge quality requirements as given in Section 7 (Technical Specifications) of Volume 2 (Employer's Requirements).

2 Functional Guarantees

2.1 Effluent and Sludge Quality

The Bidder guarantees that the effluent and sludge quality requirements specified in Section 7 of Volume 2 will be fully and completely met, under either actual or simulated design raw sewage flows, loadings, and characteristics, as demonstrated by the Tests after Completion. The bidder further guarantees that the specified requirements will continue to be fully and completely met throughout the Operation and Maintenance Period.

2.2 Symbol Definitions

The following symbol definitions shall apply for the subsequent clauses of this schedule:

U_D = Guaranteed not-to-exceed energy usage under design average influent sewage flow and BOD conditions, to be filled in by bidder (kWh per month)

U_A = Guaranteed not-to-exceed energy usage under actual monthly average influent sewage flow and BOD conditions, to be calculated per formulae provided in subsequent clauses (kWh per month)

Q_D = Design average influent sewage flow specified in bid documents (MLD)

S_D = Design average influent sewage BOD concentration specified in bid document (mg/L)

Q_A = Monthly average of actual metered influent sewage flow (MLD)

S_A = Flow-weighted monthly average of actual measured influent sewage BOD concentrations (mg/L)

2.3 Electrical Energy Usage

The Bidder guarantees that electrical energy usage of various components of the Works will not exceed the values listed in the table below, as demonstrated by the Tests after Completion and

throughout the Operation and Maintenance Period. The actual electrical energy usage shall be directly metered and compared to guaranteed numbers on a monthly average basis.

Guaranteed Power Consumption

Item	Guaranteed not-to-exceed energy usage U_D (kWh per month)
Dr Shivarama Karatha Layout STP Complete Works for 25 MLD	
Dr Shivarama Karatha Layout STP Complete Works for 50 MLD	

In case the Tenderer fails to consider any of the above said factors. The Employer has the sole authority to do necessary corrections and consider revised figures for NPV Calculation during Technical Evaluation of the Bid.

During operation and maintenance period the below formula will be applied for arriving the guaranteed power consumption based on actual flow and actual inlet sewage characteristics.

Guaranteed not-to-exceed energy usage under actual monthly average influent sewage flow and BOD conditions, to be calculated per formula below

UA (kWh per month)

$$U_A = U_D \times \frac{Q_A \times S_A}{Q_D \times S_D}$$

TECHNICAL SCHEDULE XII

CONFIRMATION OF PURCHASE AND COMPLIANCE OF

STANDARD BASIC SPECIFICATIONS

I/We hereby certify that I/We have procured one copy of each of Bangalore Development Authority (BDA): and "Standard Basic Specifications (Electrical, Mechanical, Instrumentation and Control Works)" and "Standard Basic Specifications (Civil and Structural Works)".

I/We have read the above publications and hereby confirm that I/We agree to comply with the Provisions of the above document in the bid documents.

Tenderer's Signature and Stamp/Seal of the Company

Date :

BANGALORE DEVELOPMENT AUTHORITY

Telephone: 91-80-xxxxxxxx Fax: 91-80-xxxxxxxx

Through E-Procurement

Design, Construction & Commissioning of 75 MLD (25 MLD and 50 MLD) Capacity Sewage Treatment Plant (STP) using Sequential Batch Reactor (SBR) Process Technology with Biological Nutrient, Nitrogen & Phosphorous Removal System including 6 Nos., of RCC Wet Well Cum Pump house and 8 Nos of Machine hole Pumping Stations with All Electro-Mechanical Instrumentation, SCADA and allied Civil Works for Dr. K.Shivarama Karantha Layout, Bengaluru including Five Years of O & M during operation Period

(TURNKEY CONTRACT)

STANDARD BASIC SPECIFICATIONS (SBS)

(Electrical, Mechanical, Instrumentation, Controls Works & Civil and Structural Works)

DECEMBER – 2023

Office of the Executive Engineer, Dr.K.Shivarama karantha Layout,Division-I
BANGALORE DEVELOPMENT AUTHORITY
Kumara Park West, T.Chowdaiah Road, Bengaluru-560020

PART 6

GENERAL ELECTRICAL REQUIREMENTS

PART 7

GENERAL REQUIREMENTS –
INSTRUMENTATION CONTROL AND AUTOMATION

PART 8

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CIVIL & STURCTURAL REQUIREMENTS
PART 6
GENERAL REQUIREMENTS – ELECTRICAL EQUIPMENT

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PART - 6

GENERAL REQUIREMENTS – ELECTRICAL EQUIPMENT

6.1 INTRODUCTION

This scope of this specification consists of general requirements of Design, manufacture, inspection and testing at manufacturer's works, supply, packing, forwarding and delivery to site, unloading, handling and storing the equipment at site, assembly, installation, testing and commissioning at site of the equipment/ system listed below as per Specifications, data sheets & Single Line Diagram. Particular requirements of all electrical equipments are covered under "Part 12: Particular Requirements – Electrical' of this Specification.

a) Oil cooled Transformers
b) HT Switchgear Panels
c) HT Capacitor Banks & Panel
d) FCMA Neutral Soft Start Panel
e) 415V Metal enclosed switchboards (MCCs/PCCs)
f) 415 V Power capacitor and control panel
g) Bus Duct
h) Diesel Generator Set with Acoustic Enclosure
i) UPS
j) Battery, Battery charger and DC Distribution board
k) Cabling System: HV, LV, Control and Telecommunications
l) Cable carrier system,
m) Lighting
n) Lighting System Equipment
o) Earthing & Lightning protection system.
p) Fire MCC Panel (Emergency DB)
q) Fire Alarm and Protection System

The equipment of those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, tested, Commissioned successfully and should be working satisfactorily since at least last 5 years continuously. Certificates from the end users, regarding their satisfactory Performances, shall have to be submitted in this regard.

Various equipment /items shall conform to latest applicable standards specified. In case of Conflict between standards and this specification, this specification shall govern.

6.2 TRANSFORMERS

Transformer system shall have provision such that inter-opera ability with instrumentation controls system.

A. Applicable Standards

The transformers shall conform to the latest applicable standards specified below

Power Transformer	IS:2026/BS:171/IEC:60076 IS11171
Fittings and Accessories	IS:3639
Outdoor type Oil immersed distribution transformers upto 2500kVA, 33kV Transformer	IS:1180-2014
Loading of oil immersed transformer	IS:6600/BS:CP.1010 /IEC:60354
Transformer Oil	IS:335/BS 148/IEC:60296
Bushings for > 1000V, AC	IS:2099/BS:223/IEC:60137
Bushings for ⍰ 1000V, AC	IS:7421
Degree of Protection	IS:13947 (Part 1) / IEC:60947-1
Double float type Buchholz Relay	IS:3637
Electrical insulation classified by thermal stability	IS1271/BS:2757/IEC:60085
Climate Proofing	BS:CP1014
Code of Practice for selection, installation and Maintenance of transformers	IS - 10028
Manual on Transformers	CBIP Publication No.295

B. Features of Construction

a) The transformer tank shall be made from high-grade sheet steel, suitably reinforced by stiffeners made of structural steel sections.

b) All seams, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded.

c) The interior of the tank shall be cleaned by sand blasting and painted with two coats of heat resistant, oil insoluble paint.

d) Adequately sized manholes shall be provided for ease of inspection and maintenance. Steel bolts and nuts exposed to atmosphere, shall be galvanized.

e) The tank cover shall be removable and shall be suitably sloped so that it does not retain rainwater.

f) Lifting lugs and eyebolts shall be so located that a safe clearance is obtained without the use of a spreader, between the sling and transformer bushings.

g) Transformers shall be provided with fixed type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.

h) The transformer core shall be constructed from high grade, non-ageing, cold-rolled, grain oriented, silicon steel laminations. The steel laminations shall be of "core" type. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by a copper strap connection to the tank.

i) Windings shall be of insulated copper wire or copper strip. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core. The windings shall be fully shrunk under vacuum before assembly. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.

j) The sequence and orientation of HV/LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.

k) Transformer shall operate without injurious heating at the rated KVA and at any voltage up to + 10 % of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing withstanding capability.

l) Transformer shall be provided with Zero sequence / earth fault current protection on LV side transformer feeder protection. (Neutral CT to be provided in case of solid grounding)

C. Winding connections

Windings shall be of HV: Delta & LV: Star, vector group Dyn 11.

D. Rating

The rating of transformers shall be as per standard ratings shown in IS 1180:2014 or relevant standard.

E. Type of cooling

The transformers shall be oil immersed with natural oil circulation, type ONAN. With the provision for radiator cooling with fans for forced cooling, if required will be added in future. The rating of the transformer with ONAF shall be specified.

F. Impedance and losses

The percentage impedance, no load & load losses shall be as per IS 1180: 2014 or relevant standard.

G. Performance requirements

(a) The transformers shall be suitable for operation without danger on to any particular tapping at the rated kVA provided that the voltage does not vary by more than ± 10 % of the voltage corresponding to the tapping.

(b) The transformers shall be suitable for continuous operation with a frequency variation of ±5% of rated frequency, combined voltage and frequency variation should not exceed 10 %.

(c) All transformers shall be capable of withstanding external short circuit without damage as per IS 2026.

(d) The transformers shall be capable of continuous operation in accordance with relevant IS for loading of oil immersed transformers.

(e) The neutral terminal of star windings shall be designed for the highest over current that can flow through this terminal.

(f) The temperature rise of oil & windings over the specified ambient temperature shall not exceed the limits given below with air as cooling medium when tested in accordance with IS 2026 (Part-2).

Top oil (measured by thermometer)	:	40° C
Winding (measured by resistance)	:	45° C

(g) Noise level of transformers shall be less than 80 dB at a distance of 1 metre.

H. Tap Changer

(a) The standard tapping range shall be +5% to -10% of HV in terms of 2.5 % with taps on HV Side.

(b) For transformer of rating less than or equal to 500 kVA, tap changing shall be carried out by means of an off circuit externally operated self positioning switch when the transformer is in de-energized condition. Off circuit tapping arrangement shall be either by means of an externally operated switch with mechanically locking device and a position indicator. Arrangement for pad-locking shall be provided.

(c) On Load Tap Changing Gear for Transformer (above 500kVA)

The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded i.e. 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.

(d) When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.

(e) Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. A Buchholz relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.

(f) Oil in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valve pipe connections. Any gas leaving these compartments shall pass through the Buchholz relay before entering the conservator.

(h) OLTC driving mechanism and its associated control equipment (Local) shall be mounted in an outdoor, weather-proof cabinet with IP 55 protection which shall include :

(i) Driving motor (415V, 3-phase, 50 Hz. AC squirrel cage).
(ii) Motor starting contactor with thermal overload relays, isolating switch and HRC fuses.
(iii) Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa.
(iv) Control switch: Raise/off/lower (spring return to normal type).
(v) Remote/local selector switch (maintained contact type).
(vi) Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.
(vii) Limit switches to prevent motor over-travel in either direction or final mechanical stops.
(viii) Brake or clutch to permit only one taps change at a time on manual operation.
(ix) Emergency manual operating device (hand crank or hand wheel).
(x) A five digit operation counter.
(xi) Electrically interlocked reversing contactors (preferably also mechanically interlocked).
(xii) 240V, 50 Hz. AC space heater with switch and HRC fuses.
(xiii) Interior lighting fixture with lamp door switch and HRC fuses.
(xiv) Gasketed and hinged door with locking arrangement.
(xv) Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
(xvi) Necessary relays, contactors, current transformers etc.

(g) Control Requirements for OLTC

The following electrical control features shall be provided:

(i) Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.

(ii) Only one tap change from each tap change impulse even if the control switches or push button is maintained in the operated position.

(iii) Cut-off of electrical control when manual control is resorted to. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.

(iv) Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

(h) Automatic Control of OLTC

Automatic OLTC control shall include the following items:

(i) Voltage setting device

(ii) Voltage sensing and voltage regulating devices.

(iii) Line drop compensator with adjustable R and X elements.

(iv) Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation

(v) Adjustable dead band for voltage variation

(i) The OLTC remote control equipment shall be housed in an indoor sheet steel cubicle to be located in a remote control room. It shall conform to degree of enclosure protection IP42 or better and shall comprise the following.

(j) The OLTC control panel shall comprise of rigid welded structural frames made of structural steel section or of pressed and formed cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2 mm. Stiffeners shall be provided wherever necessary.

(k) All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. Panel shall be dust, weather and vermin proof providing degree of protection of IP54, colour of finish shade for interior and exterior shall be glassy white and light grey semi glossy shade 631 of IS-5 respectively.

(l) Earthing bus shall be of 25 x 6 mm copper.

(m) The OLTC remote control equipment shall comprise of the following

(i) Control switch: Raise/Off/Lower (spring return to normal type)

(ii) Auto/manual selector switch (maintained contact type)

(iii) Tap position indicator

(iv) Facia type alarm Annunciators with "accept" and "lamp test" facilities.

- A.C. supply failure
- Drive motor auto tripped
- Tap change delayed

(v) Necessary auxiliary relays

(vi) Lamp indications for :

- Tap change in progress
- Lower limit reached
- Upper limit reached

(vii) Cable glands for power and control cables.

(viii) 240 V rated panel space heater with ON-OFF switch.

(ix) Fluorescent type interior lighting fixture with lamp and door switch.

(x) HRC fuses.

(xi) Terminal blocks.

(xii) Internal wiring.

(xiii) Earthing terminal.

I. Fittings and Accessories

The following fittings and accessories shall be provided for transformer:

(a) Inspection manhole(s) with cover(s) on the top cover of the transformer.

(b) Lifting lugs or eyes for lifting of fully assembled transformer by crane.

(c) Jacking pads, at least four in number, at suitable height, for lifting the complete transformer filled with oil.

(d) Lifting arrangements for

(i)Complete transformer filled with oil
(ii) For the assembly of core and coils and
(iii) For lifting the tank of large transformers whenever specified.

(e) Hauling eyes on each face of the transformer (for transformer rated 10000 KVA and above).

(f) Skids at the base of the transformer.

(g) A ladder assembly shall be provided to reach the top of the transformer for maintenance work. It shall be possible to padlock the ladder to the transformer tank so that ladder cannot be removed. Usage of transformer structure / marshalling boxes etc as means to climb transformer are not acceptable.

(h) Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the Employer's earthing conductors. Suitable earthing terminals on cable boxes and separately mounted radiator banks shall also be provided.

(i) Neutral earthing bar of copper of specified section installed from the neutral bushing to ground level suitably supported along its run on porcelain insulators, together with clamping arrangements at neutral bushing and for two Employer's earth conductors. The supporting insulators shall be tank mounted.

(j) Terminal marking and rating plates shall be as per the specified standard and shall also give the following additional information:

(i) Connection diagram showing the internal connections.

(ii) Guaranteed Temperature rise of winding and oil.

(iii) Insulation levels of the windings, including neutral end of windings with uniform insulation.

(iv) Transportation weight.

(v) Un-tanking weight.

(vi) Core and winding weight.

(vii) Table giving the tapping voltage, tapping current and tapping power factor for each tap. Values of short circuit impedance on the extreme tappings and on the principal tapping and indication of the winding to which the impedance is relates.

(k) The transformer shall also be provided with the following non-corrodible plates, indelibly marked showing:

(i) Location and function of all valves and plugs and indication of the maintenance instrument reference for applying vacuum of drying and oil filling.

(ii) Valves connection diagram

(l) The conservator shall be provided with the following accessories:

(i) Filling plug, sump and drain valve of 15 mm size for conservator of size 650 mm and 25 mm size for conservator above 650 mm diameter.

(ii) 150 mm diameter magnetic type oil level gauge with low oil level alarm contacts and a prismatic oil sight gauge, both as specified in Data Sheet and provided with markings for minimum oil level and oil level at rated temperature rise.

(iii) A bolted cover at one end for cleaning.

(iv) Valve for shutting off oil to the transformers.

(v) Weather proof dehydrating breather with silica gel and oil seal to eliminate constant contact with the atmosphere, mounted at a level of about 1400 mm above ground level.

(m) Gas and Oil Actuated Relay (Buchholz Relay)

(n) Temperature Indicators

(o) Dial Type Thermometer

(p) Winding Temperature Indicator

J. <u>Cable Terminations / Cabling Requirement</u>

11kV air insulated cable box with air insulated disconnecting chamber shall be provided with supporting brackets and structure to facilitate their support from ground level. The disconnecting chamber and terminal box shall be air insulated and
complete with seal-off bushings, removable flexible connectors/links and removable covers. LT terminal box shall be suitable for connecting LT air insulated bus duct.

l transformers shall be provided with lockable emergency Push Button station near the transformer to trip the transformer as per IER. All transformers shall be provided with alarm annunciation on breaker control panel.

K. Tolerance on Losses

The permissible tolerances on the guaranteed values of transformer losses shall be as per IS 2026. Cost loading shall be done for capitalization of losses at time of bid evaluation for all transformers as per CBIP Manual on transformers.

L. Rejection

(a) The Employer or Employer's Representative reserves the right to reject the transformer if the same does not meet the specification requirement, subject to tolerances as per IS 2026.

(b) The impedance values difference and temperature rise values shall not exceed from the guaranteed specified values.

(c) The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost. If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Employer's Representative reserves the right to accept the rejected transformer until the replacement transformer is made available.

(d) Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the Contractor's cost.

M. Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid/ after award of contract as specified under " Bid/Contract Drawings" , Part 3, General Requirements, Volume-2 of Bid Documents.

6.3 HT METAL ENCLOSED SWITCH BOARDS & SWITCH GEARS

HT/MV metal enclosed Switchboards and Switchgear system shall have provision such that inter-opera ability with instrumentation control system.

A. Applicable Standards

The switchgear and its components shall conform to the latest applicable standards specified below:

Circuit Breakers	IS : 13118 / BS : 5311 /IEC: 60056,60694,IEC 62271-100
Metal Enclosed switchgear	IS:3427/ BSEN:60298 / IEC:60298, IEC 62271-200
Current Transformers	IS : 2705 / BS : 7626

Voltage Transformers	IS : 3156 / BS : 7625 / IEC : 60186
Arrangement for Switchgear Busbars, Main Connections and Auxiliary wiring	IS : 5578, 11353
Busbar Support insulators	IS : 2544 / BS : 3297 / IEC :60 273
Degree of Protection	IS : 13947 (Part 1) /IEC : 60947-1/ BSEN : 60529
Electrical Relays for Power system protection	IS : 3231, 3842 / BS : 142 / IEC : 60255
Electrical Indicating Instruments	IS : 1248 / BS : 89 / IEC :60051
High Voltage Fuses	IS : 9385 / BS : 2692 / IEC : 60282
AC Electricity Meters	IS : 722, 8530 / BS : 5685 / IEC : 60145,60211
Specification for copper rods and bars for electrical purposes	IS : 613
Code of practice for phosphate iron and steel	IS : 6005 / BS : 3189 Alternating
current Switches for voltages above 1000 V	IS : 9920 / IEC : 60129,60265 & 60298
Low voltage fuses	IS : 13703 / BS 1362 / IEC 60269
Toggle switches	IS : 3452 / BS : 3676
Code of practice for selection, installation and maintenance of switchgear and control gear	IS : 10118
Control switches	IS:6875 / BSEN 60947/IEC: 60947
Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS 5572, IS 5571
Electrical apparatus for explosive gas atmospheres-General Requirements	IEC 60079
Fault level calculation	IS: 2026

B. <u>Constructional Features</u>

a) Switchgear design shall be of metal enclosed, single front, free standing, floor mounted and fully compartmental execution having separate sections for each circuit. Each Circuit shall have a separate vertical panel with distinct compartments for main bus bars, circuit breaker, cable termination and auxiliary devices.

b) The adjacent panels shall be completely separated by steel sheets except in bus bar sheet compartments where insulated barriers shall be provided to segregate adjacent panels. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits.

c) Switchgear cubicle shall be provided with hinged door on the front with facility for locking door handle.

d) Switchboard shall be dust and vermin-proof and shall have a degree of protection of enclosure of IP 4X and the relay and meter compartments shall have a degree of Protection not less than IP 52.

e) All removable covers shall be gasketed all around with neoprene or superior gaskets.

f) Instruments, relays and control devices shall be flush-mounted on hinged door of the metering compartment located in the front portion of cubicle. The metering compartment shall be properly shielded to prevent mal-operation of electronic equipment such as numerical / static relays due to electro-magnetic fields.

g) All transformers shall be provided with alarm annunciation on breaker control panel.

h) Each switchgear cubicle shall be fitted with a label on the front and rear of the cubicle. Each switchboard shall also be fitted with label indicating the switchboard designation, rating and duty.

i) Each relay, instrument, switch, fuse and other devices shall be provided with separate label.

j) The fully draw-out modules shall have all the circuit components mounted on withdraw able type steel chassis.

k) All power and control connections shall be of the draw out type. It shall be possible to withdraw the chassis mounted circuit components without disconnecting any connections. All draw-out contacts shall be of silver plated copper.

l) In case of circuit breaker compartments, suitable barriers shall be provided between breaker and all control, protective and indication circuit equipment including instrument transformers such that no live parts are accessible.

m) External cable connections shall be through separate cable compartments for power and control cables. Safety shutters shall be provided to cover up the fixed high voltage contacts on busbars when the circuit breaker carriage is moved to" test" and "isolated" positions.

n) One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal busbar compartment. However, each shipping section shall have metal sheets at both ends. After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the bus bars and adjacent circuits alive.

o) All sheet steel work shall be phosphate in accordance with the following procedure and in accordance with IS: 6005 “Code of Practice for Phosphate Iron and Steel”. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

p) After phosphate, thorough rinsing shall be clean water followed by final rinsing with dilute dichromate solution and even drying. The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved. After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The

second finishing coat shall be applied after completion of tests. The final finished thickness of paint film on steel shall not be less than 100 microns and shall not be more than 150 microns.

Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface. A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

C. Circuit Breaker

a) Circuit breakers shall be vacuum type with three separate single pole interrupting units, operated through a common shaft by a sturdy operating mechanism. Surge Arrestors shall be provided for each motor / transformer feeder.

b) Circuit Breakers shall be re strike free, stored energy operated and trip free type. Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another.

c) Anti pumping relay and trip coil suspension relay shall be provided.

d) There shall be 'Service', 'Test' 'Fully withdrawn' positions for the breakers. In the 'Test' position the circuit breaker shall be capable of being tested for operation without energizing the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected.

e) Separate limit switches, each having a minimum of 2 'NO' + 2 'NC' contacts, shall be provided for both 'Service' and 'Test' positions of the circuit breakers. All these service, test, fully withdrawn, spring charge and also breaker ON / OFF shall be visible mechanically from outside the breaker panel when the front door is closed.

f) Electrical closing & tripping shall be performed by shunt trip & close coils both in Local & Remote mode. Selector switch lockable in "Local" position shall be provided on the cubicle door. 'Red' and 'Green' indicating lamps shall be provided on cubicle door to indicate breaker close and open positions. Breaker "Service", "Test" and breaker readiness positions shall be indicated by separate indicating lamps on the cubicle door.

g) Connection of the control / interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall be preferably by means of plug socket arrangement.

h) 10% spare feeders with at least one for each type of highest rating shall be provided in each switch gear.

i) Surge arrestors shall be provided for all motors / transformer feeders and shall be metal oxide gapped or gapless type generally in accordance with IEC 60099-1and suitable for indoor only.

j) Core balance CTs (CBCT) shall be provided on outgoing motor and transformer feeders having CT Ratio 50 / 1A or more. These CBCTs shall be mounted inside the switch gear panel.

D. Operating Mechanism Control

a) Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.

b) Operating mechanism shall normally be operated from the breaker cubicle itself.

c) The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

d) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.

e) The circuit breaker mechanism shall make one complete closing operation, once the push button (PB) or control switch has been operated and the first device in the control scheme has responded, even though the PB or control switch is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.

f) Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.

g) Circuit breaker control shall be on 110 V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 80-110 % of the control voltage. Trip coils shall operate satisfactorily between 50 -110 % the rated control voltage.

E. Safety Interlocks and Features

a) Withdrawal or engagement of a circuit breaker shall not be possible unless it is in the open position.

b) All circuit breaker shall have lockable local / remote selector switch, for closing the breaker from local shall be possible only in TEST position. Whereas as closing from remote shall be possible in either SERVICE and TEST position. For opening breaker from local shall be possible only when local remote selector switch shall be in local position. Opening breaker from remote shall be either breaker in service position or selector switch being in remote position.

c) All Motors and Service Transformers feeder breaker shall have lockable emergency push button (openable only with key) near motor and service transformer, hard wired to circuit breaker panel emergency push button.

d) Operation of a circuit breaker shall not be possible unless it is in service position, withdrawn to test position or fully drawn out. It shall not be possible to close the circuit breaker electrically in the service position, without completing the auxiliary circuit between the fixed and moving portions.

e) Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the stationary isolated contacts when the breaker is withdrawn. Padlocking facilities shall be provided for locking the shutters positively in the closed position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.

f) The circuit breaker carriage shall be earthed before the breaker reaches the test position from fully withdrawn position. In case of breakers with automatic disconnecting type of auxiliary disconnects, the carriage shall be earthed before the auxiliary disconnects are made and the carriage earthing shall break only after the auxiliary disconnects break.

g) Caution nameplate, “Caution Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, i.e. incomer to the switchboard. Suitable interlock shall be wired for the purpose.

F. Earthing

a) Copper earthing bus shall be provided and extended throughout the length of the switchboard. It shall be bolted to the framework of each unit and brazed to each breaker earthing contact bar. It shall be located at the bottom of the board.

b) The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher without exceeding maximum allowable temperature rise.

c) The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.

d) Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts. Positive earthing of circuit breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

e) Hinged doors shall be earthed through flexible earthing braid of adequate cross section.

f) All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.

g) Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.

h) All instrument and relay cases shall be connected to earth busbar by means of 1100V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through each of the earth terminals.

G. Circuit / Busbar Earthing Facility

a) It shall be possible to connect each circuit or set of 3 phase bus bars of the switchboard to earth through earthing switches.

b) Earthing switches / earthing devices shall be mechanically interlocked with the associated breakers to prevent accidental earthing of live circuit or bus bars. In case the earthing facility comprises earthing trucks to be inserted in place of circuit breakers, separate earthing trucks shall be supplied for each type / size of breaker.

c) The earthing facilities proposed to be provided by the Bidder shall be clearly detailed in the Bid and shall be subject to Employer's approval. Auxiliary contacts (min. 2 NO + 2 NC)

shall be provided on each earth switch / earthing device and shall be wired to the terminal block for interlocking purpose.

H. Annunciators

a) Annunciators shall be of fascia type with translucent plastic window for each alarm point.

b) Annunciated fascia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective fascia LED light is lighted.

c) Each annunciation window shall be provided with two LED Lights to provide redundancy against LED light failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.

d) All fascia annunciated points shall be suitable to accept external contacts of either 'NO' or 'NC' self or hand reset type for initiating the annunciation sequence shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds.

e) For static Annunciator schemes, special precaution shall be taken by the Contractor to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels / desks.

f) A “Lamp Test” push button shall be provided for each individual panel's group of Annunciators to limit the sudden drain on the battery. Provision of testing facilities for flasher and audible electronics alarm circuits of annunciators is desirable. The Contractor shall give the details of the offered scheme.

g) Annunciator shall have following features:

- Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.
- During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the “lamp test” circuit and shall start flashing.
- Designed to prevent mal-operation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.
- "Alarm Supply Failure” Alarm scheme similar to the normal annunciation sequence, but shall operate on a different DC supply or on AC auxiliary supply
- Alarm annunciates having provision to integrate all alarm / trip signals to PLC.
- Alarm annunciation shall be provided for transformers, Chlorination system and surge vessel system where ever discrete local automation is envisaged.
- All Annunciations shall have interfacing facilities for communication for SCADA.

I. Indicating Instruments & Meters

a) The instruments shall be electronic / digital type with LCD display. These instruments should have high performance ratio and can be equipped with digital output (for alarms) or with interfacing facilities for communication and remote reading of parameters.

Metering Instruments

- Multi Function Meter (MFM) with the facility to measure A, V, KW, KWh, KVAr, PF, Hz with communication port.
- Multi-Function Meters shall be of the accuracy class 1.0, suitable for measurement of unbalanced loads in three phase three wire circuits.

b) MFM shall be suitable for operation from the secondary of CTs and VTs. They shall be provided with a separate 3 phase 4 wire type test blocks for the testing of the meters without disturbing the CT and VT secondary connections.

c) The instruments can be electronic / digital type with LCD display & RS 485 connectivity for remote reading of parameters in SCADA. These instruments should have high performance ratio and can be equipped with digital output (for alarms).

J. Control and Selector Switches

a) Control and instrument switches shall be heavy duty rotary type, provided with escutcheon plates clearly marked to show operating position and suitable for semi-flush mounting with only the switch front plate and operating handle projecting out. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust tight removable covers.

b) The control switches shall be 3 positions, spring return to neutral type. They shall be provided with contacts to close in 'normal after close' and 'normal after trip' position.

c) Each switch shall have external red and green indicating lamps, (except when discrepancy type switches are called for). In addition, a semaphore indicator shall be provided for earthing switch.Local / Remote selector switch shall be stay put 2 /3 position with lockable provision.

d) Contacts of the switches shall be spring assisted and contact faces shall be of silver / silver alloy. Springs shall not be used as current carrying parts. Contact rating and configurations of the switches shall be adequate for the functions desired. Lockable type switches, which can be locked in a particular position, shall be provided, if required. Emergency stop buttons, if any, shall incorporate 'stay-put' features with independent reset facilities.

K. Indicating Lights / Pilot Lights

a) Indicating light shall be rated for operation at either 230 V AC or at the specified DC system voltage as applicable. Lights shall be provided with translucent light covers.

b) Clustered LED type lamps shall be provided. Lenses shall be glass or plastic in standard colours, red, green, blue, white and amber, in accordance with IEC 60073. Miniature pilot lamps may be provided with plastic marking plate contained inside square (or rectangular) front lens to provide indication of legend or symbols engraved on the marking plate.

c) The basis of colours shall be as follows:

Red	:	Flow of energy.
Green	:	No flow of energy.
White	:	Supervision of power available, relay coil healthy, etc.
Amber	:	For all alarm conditions such as pressure low, overload, Disagreement with original condition, 'abnormal' condition or 'sequence–on' condition also for service and test position.
Blue	:	For all healthy conditions such as control supply, spring charged and lockout relay coil healthy.
Yellow :		For R, Y, B indication light, yellow as one of the light.

L. Push Buttons

a) Push buttons shall be of momentary contact type with rear terminal connections. The colour of the push button actuator shall be red for 'OPEN / STOP' and green for 'CLOSE / START'. The push button knob shall be suitably shrouded to prevent inadvertent operation. The push buttons shall be provided with integral inscription plates engraved with their designation.

b) Normal stop push button shall be mushroom type latchable in red colour, after pressing and it is latched, the latch can be removed by clockwise rotation. (Motor stops automatically after pre determined conditions such as delivery valve close in case of pumps.) This may replace stop push button.

c) Emergency stop push button red in colour shall be lockable by pressing the push button and can be opening only with key and with shrouding. (Motor stopped immediately irrespective of predetermined conditions required)Emergency Push button with shrouding shall be provided near transformer and motors for remote tripping.

d) Reset push button shall be either for resetting the flag and OLR or LEDs with push button for resetting.

e) All push buttons shall have independent, potential free, 2NO + 2NC contacts. The contact faces shall be of silver / silver alloy. The contacts shall be rated 10A and capable of breaking inductive load of 5A at 110V DC.

f) All push button shall have additional NO/NC potential free for hard wiring to instrumentation control panel.

M. Space Heaters

Adequately rated anti-condensation space heaters shall be provided for each switchboard / cubicle, bus ducts and Motors above 7.5 kW. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system. Space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a RTD thermostat to cut off the heaters at 35 degree C.

N. Cubicle Lighting / Receptacle

Each cubicle shall be provided with interior lighting by means of 18 W energy efficient (lumen per watt shall be indicated) fluorescent tube lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 240 V, 1 ph, 50 Hz, AC supply. A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

O. Power and Control Cable Termination

a) Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable aluminium solder less crimping type of lugs for terminating the cables and control cables lugs and ferrules shall be tinned copper confirming to IS 8309. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of termination provide on the equipment.

b) Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multicore cables shall be provided and shall confirm to BS: 6121. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The gland shall preferably project above the gland plate to avoid entry of moisture.

c) Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding test for appropriate high voltage for one minute.

d) Cable terminations for HV / MV cables shall be heat / cold shrinkable type. Adequately sized shrouds / bolts shall be provided at connections to completely cover the terminations.

e) Where core-balance type current transformers are provided on the feeder cables for earth fault protection, glands for cables shall be insulated from earth in an approved manner.

P. Wiring For Control and Protective Circuits

a) All low voltage wiring for control, protection and indication circuits shall be carried out with 1100 V grade, PVC insulated cable with stranded, tinned copper conductor of minimum 1.5 sq. mm size. The size of conductor for CT circuits shall be minimum 2.5 sq. mm.

b) All wiring shall be run on the sides of panels and shall be neatly bunched and cleated without affecting access to equipment mounted in the panel. The wiring shall be bound and supported by clamping, roughing or lacing. Spiral wrapping will not be accepted. Wire ways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one re-stripping and reconnection at the end of each wire. When screened cables or wires are necessary, an insulating sheath shall be included. Wiring and supports shall be of fire resistant material.

c) Wiring shall only be jointed or tied at terminals. Terminals of the clamp type shall not have more than two wires connected.

Q. Termination and Ferrules

a) Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multicore cables terminated on the panels.

b) Moisture and oil resisting insulating material shall be used. The ferrules shall be of the interlocking type and shall grip the insulation firmly without falling off when the wire is removed.

c) All wires forming part of a tripping circuit shall be distinctively marked. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

R. Control Wiring Terminal Blocks

a) Terminal blocks (TBs) shall be of 1000 V grade, 10A and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.

b) Terminals shall be numbered for identification, grouped according to function. Engraved ‘black on-white’ labels shall be provided on the terminal blocks describing the function of the circuit.

c) Terminals for circuits with voltage exceeding 110 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled. Terminals used for connecting current transformer secondary leads shall be 'disconnecting and shorting' type with a facility for earthing the secondary.

d) Terminal blocks shall be arranged with 100 mm clearance, between any two sets. Separate terminal stems shall be provided for internal and external wiring respectively. All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type of terminations.

e) At least 20 % cores shall be kept spare in multicore control cables. At least 10% spare terminals shall be provided and space for adding another 10% spares terminals shall also available in each set of TBs.

S. Bus Bars

a) The Bus bars shall be of electrical grade, high conductivity, copper and shall be provided with minimum clearances as per relevant IS. Bus bar cross section shall be uniform throughout the length of the switchgear.

b) All bus bars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing type and in fast colours to indicate phases.

c) The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals.

d) Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Busbars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint.

e) Direct access to, or accidental contact with busbars and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of busbars due to insertion of maintenance tools.

f) Sequence of red, yellow and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts respectively.

g) End terminations at transformer end and MV panel end shall be flexible bus bar such that no load / force / weight of the bus bar act on the terminal studs.

T. Current & Voltage Transformers

a) Current transformers shall be of cast resin, bar-primary type unless specified otherwise, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure and shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block. The class of insulation shall be Class E or better.

b) Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear. For wound-primary type CTs, the short time current rating shall not be less than 0.5 sec. CT core laminations shall be of high grade silicon steel. Where multi-ratio current transformers are specified, a label shall be provided, clearly indicating the connections required for the alternative ratios.

c) These connections shall also be shown on panel wiring diagrams. Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels are to be fitted on the exterior of the mounting chambers suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboard.

d) Magnetization characteristics, calculated performance and protective settings shall be provided by the Contractor. All Voltage Transformers shall be of Single Phase type. The bus VT‟s shall be housed in a separate panel in a truck so as to be fully with draw able. All Voltage transformers shall have HRC fuses on Primary and Secondary Side. There shall be provision for changeover on secondary side of Voltage Transformers to have alternate arrangement in case one Voltage Transformer fails.

U. Relays

(i) All Protective relays shall be numerical type. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity.

(ii) All numerical protective relays shall be flush mounted at the front with connections at the rear. Shall have communication port for remote, metering and monitoring facility, suitable for electrical measurement including voltage, current, power (active / reactive) and energy parameters.

(iii) All numerical relays shall have keypad to allow relay settings from relay front. Resetting knobs shall be accessible from the front on removing the external cover and shall be external to the case.

(iv) All numerical relays and timers shall be rated for control supply voltage specified and be capable of satisfactory continuous operation between 70 % and 110 % of the rated voltage.

Making, Carrying and Breaking Current ratings of the relay Contacts shall be adequate for the circuits in which they are used.

(v) The numerical relays shall have communication, Metering and Monitoring Facility. The communication facility shall have two Ports local front port (RJ45/USB) for laptop communication and the second port(Rear RS485) for SCADA.

(vi) The numerical processor shall be capable of measuring and sharing values of a wide range of quantities, events, faults and disturbance recordings with time stamping using internal real time clock. Battery backup for real time clock in the event of power failure shall be provided.

(vii) Numerical Relays shall have diagnostic feature with self check for power failure, Programmable routines, memory and main CPU Failures etc.

(viii) The Protective relays shall have adequate number of potential free contacts (Programmable). The Contacts shall be suitable for directly wiring in the breaker closing and tripping circuits operating from 110 V DC Control Voltage.

(ix) The current operated relays shall have provision for 4 Sets of CT Inputs and Voltage operated relays shall have provision for 3 PT inputs. Relays shall be suitable for CT secondary current suitable for CT Secondary current of 1 A / 5 A selectable at Site.

(x) Numerical Relays shall be immune to any kind of electromagnetic interference and capacitance effect due to length of connected control cables.

(xi) Timer function shall be programmable for ON/OFF delays.

(xii) Numerical Relays shall be able to provide supervisory function such as trip circuit monitoring, circuit breaker monitoring, PT & CT supervisions and recording facilities with post fault analysis.

(xiii) All relays shall withstand minimum test voltage of 2 KV AC RMS for one minute.

(xiv)Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.

V. Energy monitoring and power supply management

a) Necessary Provisions & features shall be incorporated to enable energy monitoring /energy management for the installation. Energy Metering shall meet the requirement of guaranteed specific energy consumption specified by the contractor through instrumentation control system.

b) In case, Numerical relays having built in features of energy measurement of requisite accuracy and provided in switch gear, separate energy meter is not required.

c) Necessary provision & features shall be incorporated to under voltage monitoring/ relay for incomer feeder, bus bar chamber and control supply.

W. I / O signal for Instrumentation, Control & Automation System from Electrical panels.

a) I/O signals from instruments shall be separately wired to a marshalling box such that instrumentation engineers will not enter in to power panel that are not familiar with them.

b) Necessary provisions shall be incorporated to meet the requirements indicated in

(i) I/O Schedules – ACB/VCB, Command Open & Close, Feedback trip, Breaker healthy (Ready to close), Local /Remote, Breaker Opened / Closed.

(ii) Data Transfer Schedule

(iii) Alarm Schedule of Particular requirement of Instrumentation, Control & Automation System, Part-13, and Volume 2 of the Bid document.

X. Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates etc. shall be submitted along with the bid/ after award of contract as specified under " Bid/Contract Drawings" , Part 3, General Requirements, Volume-2 of Bid Documents.

6.4 HT/MV CAPACITOR BANKS WITH PANEL

A. Applicable Standards

The capacitor banks and panel shall conform to the latest applicable standards specified below.

Metal enclosed switchgear	:	IS: 3427/BSEN: 60298/IEC: 60298
Current transformers	:	IS: 2705/BS: 7626
Arrangement for switchgear busbars, Main connections and auxiliary wiring		IS: 5578/IS: 11353
Busbar support insulators	:	IS: 2544/BS: 3297/IEC: 60273
Degree of protection	:	IS: 13947 – Part (I)/IEC: 60947-1
High voltage fuses	:	IS: 9385/BS: 2692/IEC:60282
Specification for copper rods and	:	IS: 613

Bars for electrical purposes		
Code of practice for phosphating iron and steel	:	IS: 6005/BS: 3189
Load break switches	:	IS: 9920, IEC: 129, 265, and 298
Shunt capacitors for power systems	:	I S: 2834
Series reactor	:	I S: 5553
Internal fuses and internal overpressure disconnectors for shunt capacitors	:	IS: 12672
Porcelain post insulators	:	IS: 2544

B. Design Features

(a) The panel shall be indoor, metal clad with separate metal enclosed compartments for

(i) 11 kV capacitor banks
(ii) Load break switch with fuse
(iii) Busbars
(iv) Core balance current transformers
(v) Power cable terminations.

(b) Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.

(c) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer paint. After application of the primer, two coats of finishing synthetic enamel paint ovenbaked/stoved shall be applied.

(d) The cable compartment shall house all power cable connections along with associated cable terminations. Zero sequence current transformers provided for earth fault protection shall be located inside the cable compartment.

(e) Each cubicle shall be fitted with a label in the front and rear of the cubicle. Each capacitor bank, switch, fuse and other devices shall be provided with separate labels, indicating designation rating and duty.

(f) The capacitor bank shall be complete with accessories and shall be metal enclosed, indoor floor mounting and free standing type.

(g) The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the series parallel combination of capacitor units shall be such as not to exceed the permissible overvoltage across the healthy capacitor units in case of failure of one or more units.

(h) The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers may be provided in the cubicle to ensure proper ventilation.

(i) Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors and reduce the voltage to less than 50 volts within five minutes.

(j) The capacitor banks shall be suitable for continuous operation at 110% of rated rms voltage.

(k) The capacitor bank shall be suitable for continuous operation at 150% of rated rms current.

(l) Bushings shall be of porcelain and shall be joined to case by soldering/welding or other method which ensures an adequate and permanent seal.

(m) Each unit active parts shall be non-inflammable dielectric immersed in suitable impregnant, self cooled, and hermetically sealed. The impregnant shall be non-PCB (Poly chlorinated Biphenyl) oil.

(n) Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse breaking time shall coordinate with the pressure built up within the unit to avoid explosion.

(o) Mounting of the individual fuse may be internal or external to the capacitor case.

(p) The switching and protective devices and the connections shall have a capacity corresponding to 1.5 times the rated current of the capacitor bank.

C. Main Busbars

(a) Busbars shall be fully insulated by encapsulation in epoxy resin, with moulded caps protecting all joints.

(b) Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit.

(c) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity.

D. Disconnection Switches

(a) Disconnect switches shall be load break, type. Push button with indicating lamps shall be provided for the opening of the load break switch.

E. Earthing

(a) An earthing bus shall be provided at the bottom and extended throughout the length of the cubicle. It shall be bolted/ welded to the frame work.

(b) All non-current carrying metal work of the cubicle shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

F. Panel Accessories and Wiring

(a) Panel shall be supplied completely wired internally upto equipment and terminal blocks and ready for the external cable connections at the terminal blocks.

(b) All auxiliary wiring shall be carried out with 650 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 $mm^{2.}$

(c) Terminal blocks shall be of stud type, 650 volts grade 10 amps, rated complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities.

(d) All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.

(e) Push buttons shall be provided wherever specified. They shall be provided with inscription plates engraved with their functions.

(f) Indicating lamps shall be panel mounting type with series resistors. The wattage of lamps shall be 5 to 10 watts.

(g) Each panel shall be provided with 240 volts, 1 phase, 50 Hz, 5 amps, 3 pin receptacle with switch located in a convenient position.

(h) An interior illuminating lamp together with operating door switch and protective fuse shall be provided.

G. Cable Termination

(i) Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring etc.

(ii) Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper/aluminium depending on cable conductor and of solderless crimping type

(iii) All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc. shall be supplied.

H. Drawings and Data

All Drawings, data, technical particulars ,calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified in, " Bid/Contract Drawings" , Part 3, General Requirements, Volume-2 of Bid Documents.

6.5 FCMA NEUTRAL SOFT START PANEL

A. Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

Metal enclosed switchgear	:	IS: 3427
Current transformers	:	IS: 2705/BS: 7626
Arrangement for switchgear busbars, Main connections and auxiliary wiring		IS: 5578/IS: 11353
Busbar support insulators	:	IS: 2544/BS: 3297/IEC: 273
Degree of protection	:	IS: 13947 (Part I) /BSEN: 60529/ IEC: 947-1
Electrical relays for power system Protection	:	IS: 3231/BS: 142/IEC: 255
Electrical indicating instruments	:	IS: 1248/BS: 89/IEC: 51
A.C. electricity meters	:	IS: 722/BS: 2692
Specification for copper rods and bars for electrical purposes	:	IS: 613
Code of practice for phosphating iron And steel	:	IS: 6005/BS: 3189

B. Constructional and Performance Features

(a) Flux Compensated Magnetic Amplifier (FCMA) neutral soft start panel shall be indoor, metal clad with separate metal enclosed compartments for (i) control, metering and current transformers for differential protection (ii) shorting switch (iii) busbars (iv) power cable terminations (v) push buttons with indicating lamps.

(b) FCMA shall achieve smooth starting by torque control for gradual acceleration of the drive system thus preventing jerks and extending the life of equipment.

(c) Starting current shall be limited to 3.0 times the full load current of the motor.

(d) Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.

(e) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer plant. After application of the primer, two coats of finishing synthetic enamel paint oven baked/ stoved, shall be applied.

(f) The cable compartment shall house all power cable connections along with associated cable terminations.

(g) Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

(h) Caution name plate with inscription "Caution - Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, e.g. incoming terminals of main disconnecting switch.

(i) Starting of motor shall be from either FCMA panel located near to motor or shall be from 11 kV motor modules or from PLC. Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

C. Main Busbars

(a) Busbars shall be fully insulated by encapsulation in epoxy resin, with moulded caps protecting all joints.

(b) Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit.

(c) Busbars shall be of copper conductor of hand drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.

D. Earthing

(a) An earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted/ welded to the frame work.

(b) All non-current carrying metal work of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

E. Panel Accessories and Wiring

(a) Panel shall be supplied completely wired internally upto equipment and terminal blocks and ready for the external cable connections at the terminal blocks. Inter panel wiring between compartment of the same panel shall be provided.

(b) All auxiliary wiring shall be carried out with 650 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 mm^2.

(c) Terminal blocks shall be of stud type, 650 volts grade 10 amps rated, complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities.

(d) All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.

(e) Accuracy class for indicating instruments shall be 2.0 or better. Instruments shall be 110 mm square, 240° scale for flush mounting with only flanges projecting.

(f) Relays shall be suitable for flush mounting with only flanges projecting.

(g) All protective relays shall be in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose and shall be included. All auxiliary relays and timers shall be supplied in non-draw-out cases. Externally operated hand reset flow indicators shall be provided on all relays and timers. Timers shall be of electromagnetic or electronic type only.

(h) Push buttons shall be provided with inscription plates engraved with their functions.

(i) Indicating lamps shall be panel mounting type with series resistors. The wattage of lamps shall be 5 to 10 watts.

(j) Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 240 V, 1 ph, 50 Hz supply. They shall be complete with HRC fuses, isolating switches and thermostat.

(k) Each panel shall be provided with 240 Volts, 1 phase, 50 Hz, 5 amps, 3 pin receptacle with switch located in a convenient position. An interior illuminating lamp together with the operating door switch and protective fuses shall be provided.

(l) Provision shall be made for receiving, distribution, isolating and fusing of auxiliary D.C. and A.C. supplies for controls, space heating etc. The fuse ratings shall be so chosen as to ensure selective clearance of subcircuit faults.

(m) Fuses shall be HRC cartridge type mounted on plug in type fuse base.

(n) The D.C. and A.C. auxiliary supply shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit fuses as required.

F. Cable Termination

(a) Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring etc.

(b) Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper/aluminium depending on cable conductor and of solderless crimping type

(c) All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc. shall be supplied.

G. Drawings and Data

All Drawings, data, technical particulars ,calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified " Tender/Contract Drawings" , Part 3, General Requirements, Volume-2 of tender documents.

6.6 415 V METAL ENCLOSED SWITCHGEARS / MCC

A. Applicable Standards

The switchgear and its components shall conform to the latest applicable standards specified below. .

Switchgear General Requirements	IS:13947/BS:5486/IEC:60947
Factory Built Assemblies of SWGR and Controlgear for Voltages upto and including 1000V AC & 1200V DC	IS:8623/BS:5486/IEC:60439
Air Break Switches	IS:13947-P3 /BSEN60947 /IEC:60947-3
Moulded Case Circuit Breaker	IS 2516 / IEC 60947-2/ BS EN 60947-2
Miniature Circuit Breakers	IS:8828/BSEN:60898
Low voltage Fuses	IS:13703/BS:1362/IEC:60269-1
Contactors	IS:13947/BS EN60947-4 /IEC:60947-1
Starters	IS:13947/BS EN60947-4/ IEC:60292-1TO 4
Control Switches / Push buttons	IS:6875 / BSEN 60947
Current Transformers	IS:2705/BS:7626
Voltage Transformers	IS:3156/BS:7625/IEC:60044, 60186
Indicating instruments	IS:1248/BS:89/IEC:60051
Marking and Identification of Conductors and Apparatus Terminals	IS:11353/BS:159
A.C. Electricity Meters	IS:722, 8530/BS:5685 / IEC 60145,60 211
Degree of Protection	IS:13947/IEC:60947-P1
Selection installation and maintenance of switchgear and controlgear	IS:10118
Code of practice for phosphating iron and steel	IS:6005/BS:3189
Specification for copper rods and bars for electrical purposes	IS:613
Control transformers for switchgear and controlgear voltage not exceeding 1000V AC	IS:12021

Features of Construction

(a) The switchgear shall be metal enclosed, dust proof, modular type, suitable for indoor floor mounting and shall have following features.

(i) Total height of switchgear shall not exceed 2300 mm. Height of Switches, Pushbuttons shall not exceed 1800 mm and shall not be less than 700 mm.

(ii) Shall be double front execution and fixed type

(iii) Shall have designation labels both on front and rear sides

(iv) Shall be provided with proper gasketing for removable covers, doors, between panels and base frame and all around the perimeter of adjacent panels.

(v) Degree of Protection shall be IP54.

(vi) Thickness of CRCA Sheet is 2mm.

(b) Switchgear shall be divided into distinct vertical sections each comprising :

(i) A completely enclosed busbar compartment running horizontally

(ii) Enclosed vertical busbars serving all modules in vertical section

(iii) A separate horizontal enclosure for all auxiliary power and control buses if required

(iv) Vertical cable alley of 250mm wide covering entire height

(c) Operating devices shall be incorporated only in the front of switchgear.

(d) Each shipping section shall have metal sheets at both ends.

(e) Cable alley shall be provided with suitable hinged doors.

(f) GS/GI Earth bus of size 50mm x 10 mm shall be provided at the bottom.

(g) Rear of Single Front Switchgear shall be provided with removable panels with screws.

(h) All doors shall be with concealed type hinges and captive screws.

(i) Each vertical section shall be equipped with 240 V, 1 Phase, 50 Hz space heater controlled by thermostat.

(j) A 240 V, 1 phase, AC plug point shall be provided in the interior of each cubicle with on-off switch for correction of head lamps.

(k) Interchangeability

All identical equipment and corresponding parts be fully interchangeable without any modifications.

(l) Main and Auxiliary Buses

(i) Switchgear busbars shall be of uniform cross section throughout the length and made of high conductivity, electrical grade hard drawn copper conductor.

(ii) Busbar shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints and shall be adequately supported to withstand stresses

developed due to short circuits. Supports shall be of glass reinforced phenolic material or cast resin.

(iii) Busbar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts and Belleville washers and nuts.

C. Air Circuit Breaker (ACB)

(a) Air circuit breaker shall be selected for feeders for load current equal to and more than 630A.

(b) Circuit breakers shall be operated by a motor spring charging type of mechanism. The motor operated spring charged mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.

(c) The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

(d) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.

(e) The circuit breaker mechanism shall make one complete closing operation, once the push button has been operated and the first device in the control scheme has responded, even though the PB is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.

(f) Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall be provided on the operating mechanism.

(g) All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication.

(h) Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110 % of the control voltage. Trip coils shall operate satisfactorily between 70 -110 % the rated control voltage.

(i) The Breaker shall be provided with Microprocessor based releases for Inverse-time delayed overload releases for the phases, Short-time delayed short-circuit releases and earth-fault releases.

(j) The breaker service Short Circuit breaking capacity (ICS) shall be equal to ultimate Short Circuit capacity (ICU)and shall be equal to short time withstand current of Breaker (ICW)

D. Moulded Case Circuit Breaker (MCCB)

(i) MCCBs shall be of the air break, quick make, quick break and trip free type and shall be totally enclosed in a heat resistant, moulded, insulating material housing. MCCBs shall have an ultimate short circuit capacity not less than the short circuit current Specified .MCCBs shall have a service short circuit breaking capacity $_{(ICS)}$ equal to the ultimate short-circuit capacity (I_{CU}).

(ii) Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism. Thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated.

(iii) The MCCBs shall be provided with the following features.

(i) Common trip bar for simultaneous tripping of all poles

(ii) Shrouded terminals

(iii) Time for clearing short circuit current of 20 msec.

(iv) 2 NO + 2 NC auxiliary contacts

E. Switches and Fuses

(a) 415 V air-break switched shall be of the load break, fault make, group operated type. For use on 3-phase systems, the switches shall be of the triple pole type with a link for neutral wire. For use on single phase system and d-c systems, the switches shall be of the two pole type.

(b) Switches shall be of the heavy duty, quick make and quick break type. Switch contacts shall be silver plated, and contract springs shall be of stainless steel. Switch handles shall have provision for locking in both fully open and fully closed positions. Mechanical ON-OFF indication shall be provided on the switches.

(c) Switches for controlling motor circuits shall be of the load break, fault make type, and shall be capable of breaking locked rotor current of the associated motor.

(d) 415 V switches and fuses shall be provided with the following interlocks so that :

(e) The fuses are not accessible unless the switch is in fully open condition

(f) It is not possible to close the switch when the fuse cover is open, but an authorised person may override the interlock and operate the switch. After such an operation, the cover shall be prevented from closing if the switch is left in the 'ON' position.

(g) All fuses shall be of the HRC cartridge type, mounted on plug-in type of fuse bases. Fuses shall be provided with visible indicators to show that they have operated.

(h) Earthing and neutral lines in main supply circuits shall be of solid silver plated copper and be of the bolted pattern.

(i) Fuses and links functionally associated with the same circuit shall be mounted side by side.

F. Miniature Circuit Breaker (MCB)

(a) MCB shall be hand operated, air break, quick make, quick break type.

(b) Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

(c) Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the connected load. Where this is not specified, it shall be Type C. The short circuit rating shall be not less than that of the system to which they are connected.

G. Contactors

(a) The power contactors used in the switchboard shall be of, air break, single throw, triple pole, electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with the latest edition of IS 13947.

(b) Operating coils of all contactors shall be suitable for operation on 240 V, single phase, 50 Hz supply. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts. Contactors shall not drop out at voltages down to 70 % of coil rated voltage. Contactors shall be provided with a three element, positive acting, ambient temperature compensated, time lagged, hand reset type thermal overload relay with adjustable settings. The hand reset button shall be flush with the front door of the control module, and shall be suitable for resetting the overload relay with the module door closed. Relays shall be either direct connected or CT operated. Overload relay and reset button shall be independent of the "Start" and "Stop" push buttons. All contactor shall all be provided with single phasing preventer (SPP).

(c) Motor starters shall be complete with auxiliary relays, timers and necessary indications.

H. Current Transformers

(a) Current Transformers shall be Cast Resin type.

(b) Current transformers shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block.

(c) Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear, as indicated in the Technical Specification.

(d) CT core laminations shall be of high grade silicon steel.

(e) Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.

I. Voltage Transformers

(a) Voltage Transformers shall be Cast Resin type.

(b) Secondary and tertiary windings of voltage transformers shall be rated for a three phase line to line voltage of 110 V.

(c) It shall be possible to replace voltage transformer fuses easily without having to de energiser the main bus-bars.

J. Indicating Instruments & Meters

(a) Electrical indicating instruments shall be 110 mm square with 240º scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers. Instrument dials shall be white with black numbers and lettering.

(b) Normal maximum meter reading shall be of the order of 60 % normal full scale deflection. Ammeters for motor feeders shall have suppressed scale to show current from full load up to six times the full load current. Watt hour meters shall be of the induction type and shall be provided with reverse running stops. Instruments shall have an accuracy of Class 1.0.

K. Indicating Lamps

Indicating lamps shall be of the cluster LED type, with low watt consumption. Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 240 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers. Bulbs and lenses shall be interchangeable and easily replaceable from the front.

L. Push Buttons

"Start" and "Stop" push buttons shall be coloured green and red respectively. Stop Push Button shall be lockable stay-put type with Mushroom head.

M. Space Heaters

Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk.Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system. Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control thermostat to cut off the heaters at 350 ^{0}C.

N. Safety Arrangements

All terminals, connections and other components, which may be “live” when front access door is open, shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle or module when any door is opened. Components within the cubicles shall be labelled to facilitate testing.

O. Earthing of Switchboards / Panels

(a) Each switchboard, control panel, etc. shall be provided with an earth busbar running along its entire length. The earth bus bar shall be located at the bottom of the board/panel.

(b) Earth bus bars shall be of copper and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second, unless otherwise specified. Earth bus bars shall be properly supported to withstand stresses induced by the momentary short circuit current of value equal to the momentary short circuit rating of the associated switchboard/panel.

(c) Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.

(d) All instrument and relay cases shall be connected to earth bus bar by means of 1100 V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through the case earth terminals.

P. Internal Wiring

The internal wiring shall be carried out with 650/1100V grade, PVC insulated, stranded conductor wires. The minimum size of conductor for power circuits shall be 4 Sq.mm copper or equivalent size aluminium conductor. Control circuits shall be wired with copper conductor of atleast 1.5 Sq.mm.

Q. I / O & Other Data for Instrumentation, Control & Automation System

Necessary provisions shall be incorporated to meet the requirements indicated in

(a) I / O Schedules

(b) Data Transfer Schedule

(c) Alarm Schedule

Of Particular requirement of Instrumentation, Control & Automation System, Part-13, Volume -2.

R. Drawing and Data

All Drawings, data, technical particulars , calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified, " Tender/Contract Drawings" , Part 2, General Requirements, Volume-2 of Tender Documents.

6.7 415 V POWER CAPACITOR AND CONTROL PANEL

A. Applicable Standards

The capacitor and control panel conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern

Shunt capacitors for power systems	IS : 13340
Internal fuses and internal overpressure disconnectors shunt capacitors	IS : 12672 for
Metal enclosed switchgear	IS : 3427 / BSEN 60298 / IEC : 60298
Code of practice for phosphating iron and steel	IS : 6005/BS : 3189
Specification for copper rods and bars for electrical purpose	IS : 613

B. Design Features

(a) The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.

(b) The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanised.

(c) The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an overvoltage on the units in parallel with it, which will result in the failure of the parallel units.

(d) The complete capacitor banks with its accessories shall be metal enclosed (in sheet steel cubicle), indoor floor mounting and free standing type.

(e) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with

two coats of zinc rich primer paint. After application of primer, two coats of finishing synthetic enamel paint oven baked/stoved shall be applied.

(f) The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers may be provided in the cubicle to ensure proper ventilation.

(g) Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of the latest edition of IS : 2834.

(h) Capacitors shall be of Mixed Dielectric of polypropylene and paper with internal element fuses. The impregnant shall be non PCB (poly chlorinated biphenyl) oil.

(i) Each unit shall satisfactorily operate at 135% of rated KVAR including factors of overvoltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any overvoltage upto a maximum of 10% above the rated voltage, excluding transients.

(j) Unit Protection

Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse braking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor case.

C. Power Capacitor and Control Panel

(a) Power capacitor and control panel shall be housed in metal enclosed cubicle. Power capacitor shall be housed in the lower compartment and capacitor control panel at top compartment.

(b) The control equipment including capacitors shall be mounted in a panel of cold rolled sheet steel. The panel shall be of indoor type and shall consist of :

(c) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity

(d) Isolating switch

(e) Contactor with overload element

(f) Relays responsive to current/voltage/KVAR/PF as specified for automatic switching

(g) Sequencing devices, timers and auxiliary relays for automatic sequential switching of the capacitors in and out of the circuit.

(h) Auto-manual selector switches

(i) Push button for opening and closing the power circuit.

(j) Red and green lamps for capacitors ON/OFF indication.

(k) Protective relays to protect the healthy capacitor units when one unit fails in a series connection

(l) Space heater and cubicle lighting as per the requirements.

D. Drawings and Data

All Drawings, data, technical particulars ,calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified, " Bid/Contract Drawings" , Part 2, General Requirements, Volume-2 of Bid Documents.

6.8 415V BUS-DUCT

(a) All bus-ducts will be of non-segregated metal enclosed phase with cross over chamber (if required), all bends and accessories like flexible expansion joints, terminal connectors and flanges, wall frame assembly etc.

(b) The Bus-bar shall be

(i) Electrolytic grade copper
(ii) 99% purity
(iii) 97% Conductivity

(c) The metal enclosed bus duct shall be designed to operate continuously under the conditions specified in Data Sheet.

(d) The material of the enclosure shall be CRCA with minimum thickness of 2 mm.

(e) Bus-duct enclosure will be of MS epoxy painted with outer shade of Siemens grey RAL 7032 & black matt paint on the inside. Paint thickness shall be 140 microns or above.

(f) Wall frame assembly shall be provided if required.

(g) The enclosure shall be totally enclosed, dust & vermin proof with ventilation louvers.

(h) All nuts, bolts, hardware used for Bus-duct shall be of M12 size, grade 8.8 & of cadmium.

(i) All joints in the enclosure shall have neoprene gaskets.

(j) The Bus-duct shall comply with the technical parameters of the latest version of the IS/ IEC.

(k) The bus duct shall be inclusive of the following:

i. Straight run of the duct
ii. 90 deg bends
iii. Copper flexible at Transformer end
iv. Copper flexible at LT DG end
v. Copper flexible at LT panels end.
vi. Wall frame assembly and seal off bushing
vii. Phase crossover chamber

(l) The bidder shall submit type test certificates along with the bid for Bus duct for The following:

i) S.C. withstand capacity for 1 second.
ii) Degree of protection.
iii) Temperature rise.

6.9 DIESEL STANDBY GENERATOR

A. Applicable Standards

The Diesel Standby Generator and its components shall conform to the latest applicable Standards specified below:

Diesel Engines for General Purposes	: BS 5514 / ISO 3046
The Electrical Performance of Rotating Electrical Machinery	: BS 5000
Rotating Electrical Machines	: IS 4722
Circuit breakers	: IS-13118, BS-5311, IEC-56 & 694, BSEN-60942 (P-2)
Air break switches air break disconnectors, air break switch disconnectors and fuse combination units for voltage not exceeding 1000 V AC or 1200 V DC	: IS-13947 (P-3), BS-EN60947, IEC-60947-3
Current transformer	: IS-2705/BS-7626, IEC-60185
Voltage transformer	: IS-3156/BS-7625/IEC 60186
Electrical Relays	: IS-3231,3842/BS-142/IEC-60255
Contactors for voltage not exceeding 1000 V ac or 1200 VDC	: IS-13947 Part-IV/ BSEN-60947-4-1/ IEC-60947-4-1
Control Switches	: IS-6875/BSEN-60947 / IEC-60947-4-1

High Voltage Fuse	IS-9385/BS-2692/ IEC-60282
Low Voltage Fuse	IS-13703/BS-1362 IEC-269-1
Electrical direct acting indicating Instruments	IS-1248/BS-89/IEC-60051
A.C. electricity metres of induction type voltage greater than1000 volts	IS722, 8530/BS-5685 / IEC-60145, 60211
Resistance wire, tapes and stripes for heating elements	IS-3725
Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes	IS-5082
Specification for copper rods and bars for electrical purposes	IS-613
Toggle switches	: IS-3452/BS-3676
Control switches/push buttons	: IS-6875/BSEN 60947
Noise and Emission Limit	: As per latest notification of ministry of Environment and Forests

B. General Requirements

(a) The diesel engine shall draw cooling air directly from outside the room through a weatherproof, acoustically treated duct. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to personnel. The exhaust system pipe shall be 2 Meters above the nearest building as per CPCB. The exhaust pipe line diameter shall be suitably designed to avoid back pressure when discharged at higher elevation. The silencer shall be of the 'residential' type and be located externally.

(b) The generation voltage shall be 415V for D.G capacity less than 2 MVA and generation voltage shall be 11kV for D.G capacity more than 2 MVA. Even if one D.G set is required for achieving the required capacity they shall be operated in parallel with necessary synchronizing arrangement with LCD.

(c) At no point D.G sets will be operating parallel with grid. The diesel engine fuel shall be stored in an above ground bulk storage steel tank to be located adjacent to the generator room at a site accessible for filling to local road tankers.

(d) The storage tank shall be sized to store fuel for 1 day running of the engine at full load. The tank shall be provided with fittings to permit the visual observation of fuel level and filling by local tanker operators. A level sensor shall also be mounted in the tank so that remaining fuel volume can be monitored at the generator / substation PLC and the operator stations in the SCADA room.

(e) The fuel storage tank shall be located in a bund capable of holding not less than 125% of the maximum storage tank contents. Fuel transfer pumps shall be provided to automatically transfer fuel from the bulk storage tank to a high level 990 litres day tank located in the generator room

or generator skid mounted day fuel tank. A semi-rotary hand pump shall be provided to permit transfer of fuel in the event of a failure of the transfer pump.

(f) Any leakage from the pumps shall be routed to the bund. A system shall be provided within the generator room to detect fire, to raise a local audible alarm (manually silenced locally) and if a high level day tank is used, to automatically dump the day fuel back to the bulk storage tank.

(g) The Fuel system shall be constructed such that leakage of water, fuel or oil within the generator room shall be routed to a local sump where a detector shall be provided to raise an alarm. Adequate sensors shall be provided to detect the fault and shall be wired to control panel.

(h) The system shall be constructed such that the leakage of fuel or the accumulation of water within the fuel storage bund shall be detected and shall raise an alarm.

(i) All alarms shall be conveyed to the central HMI through the PLC.

C. Diesel Generating Set Automatic Control

(a) AMF Diesel Generator Set capable of automatic starting and picking the load within 30 seconds shall be provided to cater for emergency loads and lighting during mains power failure.

(b) Diesel generating set for use in auto mains failure mode shall have a three position automatic /off /manual selection and shall operate as follows:

(i) Automatic mode :
On occurrence of mains failure the following sequence shall be followed.

a) Mains to Generator changeover
- mains failure detected
- delay of 10 seconds
- generator is started and run up to speed
- time delay of 50 seconds
- mains supply is switched off
- generator supply is switched on

b) Generator to Mains changeover
- mains healthy detected
- manual changeover signal received,
- generator supply is switched off
- mains supply is switched on

- generator runs for 2 minutes and stops

All timer settings shall be adjustable.

(c) If mains power is restored during the initial one minute delay then the power shall be monitored for a further one minute and if it is still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after three attempts the system shall shut down and a local and remote alarm shall be annunciated.

(ii) Manual mode:

(d) The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

D. Alternator for Diesel Generating Set & Biogas Generator Set

(a) The generation voltage shall be 415V for capacity less than 2 MVA and generation voltage shall be 11kV for capacity more than 2 MVA.

(b) Alternator shall be 4 pole, 3 phase, 50 Hz, 0.8 P.F, salient pole, revolving field, Brush less type, self-regulating continuously rated and manufactured in accordance with IS 4722, BS 5000: Part 99 or IEC 60034-1. They shall be totally enclosed, screen protected, fan ventilated and vertical drip-proof conforming to IP 23.

(c) The Alternator shall be complete with excitation system, AVR and all necessary auxiliaries. The alternator shall be driven by diesel engine detailed below and shall match the same in all respects.

(d) The terminal box shall be dustproof with IP 54 degree of protection. The terminal box shall be suitably sized to terminate the size and number of cables involved.

(e) Alternators shall be capable of withstanding a 10% overload for 1 hour in any 12 hour Period under the specified conditions of temperature, humidity and atmospheric pressure. Alternator windings shall be of Class H insulation with Class F temperature rise and tropicalised.

(f) The alternator shall have pre-packed grease lubricated ball or roller bearing sand provided with facilities for degreasing whilst in service. The alternator shall be foot mounted on a common bed frame with the prime mover close coupled to the engine flywheel housing. The direction of alternator rotation when viewed from the driven end shall be clockwise and phase voltage sequence UVW.

(g) The alternator vibration level shall not exceed the values defined in IS 12075.The alternator shall be capable of maintaining a short circuit current of three times full load current for a period of 10 seconds. The alternator shall be fitted with an anti-condensation Alternator shall have 6 Nos. duplex RTDs inside the stator winding. No individual harmonic shall exceed 1% and the total harmonic shall not exceed 3%.

(h) The alternator, it's neutral and control panel shall be earthed as per relevant standards. Alternator rotor assembly shall comprise exciter rotor, full wave silicon bridge rectifier, surge protection device and salient pole rotating field system. The rotor shall be fitted with interconnected pole face damping windings. Voltage regulation shall be maintained to within ±2.5% for a power factor of 0.8 to unity, including hot to cold variations.

(i) The steady state frequency droop between no load and full load shall not exceed 5%.Transient voltage deviation following a step load of 60% of rated at a power factor of between 0.4 and zero shall not exceed 15% with a voltage recovery time to 97% rated voltage not exceeding 0.5second.

(j) The set shall be capable of continuous operation with a phase current imbalance of 33% of rated current whilst maintaining the output voltage within ±5% of rated. Alternator shall have sensors for alternator protection and shall be wired to control panel.

(k) The alternator shall be provided with class F insulation with temperature rise limited to that of class B insulation.

E. <u>Diesel Engine for Generating Set</u>

(a) Engine shall be four-stroke, direct injection, and turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water cooled and shall be direct coupled to the alternator and mounted on a common rigid steel bedplate.

(b) Engines shall be rated for continuous duty at site ambient conditions with an inherent O/ L Capacity of 10% for 1 hour in any 12 hours.

(c) The engine shall be capable of running at full load for not less than 180 hours without maintenance adjustments and 10,000 hours between major overhauls. The maximum operating speed shall be 1 500 rpm. The range of manual adjustment shall not be less than ±5% of rated speed. The performance of engine governors under load conditions shall be to Class A2 in accordance with BS 5514: Part 4.

(d) Engine governors shall be suitable for remote control load sharing between identical engine units. In addition to any electrical over speed trips, there shall be a mechanical over speed device which shall operate at 120% of the rated speed. Re-setting of the over speed trip shall be possible by hand only.

(e) The steady state output speed drop between no load and full load shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%. Engines shall be designed to run on fuel oil complying with IS 1460 or BS 2869, Class A2.

(f) Engines shall be cooled by means of a water jacket, heavy duty air blast radiator with integral radiator header tank, circulating pump and engine driven pusher type fan. The fan shall draw air in from the vicinity of the engine block and discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it is located directly behind automatic louvers set into the external wall of the engine room. A thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling the engine oil. A thermostatic by-pass valve shall be incorporated.

(g) Engine lubrication shall be by a closed circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand operated semi-rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer.

(h) The starting system shall comprise 12 or 24 V heavy duty lead acid batteries (positioned on a floor mounted stand adjacent to the engine) connected by heavy duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine at 0°C. An engine driven alternator and charging system shall be provided. An automatic mains energized battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to full fill the starting requirements.

(i) Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be arranged so that normal starting of the engine is inhibited whilst the hand turning equipment is connected.

(j) Twin heavy duty air intake filters in accordance with IS 3169 or BS 7226 suitable for operating in dust laden atmospheres shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbo charger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.

(k) Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250 kVA), and water temperature and battery charge current. The bedplate shall be of heavy gauge steel construction, stress relieved and free from distortion. Engine shall be provided with sensors for engine protection and shall be wired to control panel.

(l) Machined surfaces shall be incorporated for mountings and for levelling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for levelling purpose and shall be designed to resist horizontal movement of the diesel set.

(m) The fuel System shall comprise an engine driven feed pump with duplex filters, 990 litres day tank with supporting structure or generator skid mounted day fuel tank, with all inter connecting pipe work , flexible engine connection pipe etc.

F. <u>Diesel Generator Control Panel:</u>

(a) The control panel shall have provision such that inter-opera ability with instrumentation control system. The control panel with communication facility shall be separately mounted on anti vibration mountings and shall comprise the following:

(i) Breaker incorporating short circuit and overload trip
(ii) Earth fault protection for the Alternator
(iii) Alternator Over & Under Voltage Protection
(iv) Voltage Controlled Over Current Relay
(v) Voltmeter with built in selector switch /(digital)

- ammeter with built in selector switch / (digital)
- frequency meter
- Power Factor Meter
- KWH Meter (Multifunction meter)
- engine temperature and oil pressure gauge
- service hours run indicator
- key switch start and stop control
- operational status indicator
- anti-condensation heater and thermostat
- alternator anti-condensation heater controls

- mains fed battery charger
- Auto start on mains power supply failure facility
- Fails to Start (Alarm)
- Over / Under Voltage (Alarm)
- Battery Charger Fault (Alarm)
- Low fuel Oil Level (Alarm)
- Over Load (Alarm)
- Low Lube Oil Pressure (Trip)
- High Water Temperature(Trip)
- High Lube Oil Temperature (Trip)
- Electrical Protection Relays (Trip).

(b) A reset button shall be provided to cancel the alarm /shut-down condition prior to restarting.

(c) Simple operating instructions shall be detailed on the fascia of the control panel. All alarm and trip status signals from diesel supply system, engine control panel and alternator protection shall be hard wired to a marshalling box for instrumentation control system.

G. Synchronising Panel

Whenever two or more sets are required to operate together, necessary synchronizing panel complete with circuit breaker, synchroscope, numeric relays, digital meters etc shall be provided. The Panel shall be floor standing, CRCA Sheet steel enclosed.

H. Acoustic Enclosure

(i) The DG Set shall be provided with acoustic enclosure, fully integrated, weather proof with superior finish for long and durable life.

(ii) The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire retardant foam/glass wool as acoustic material.

(iii) The sound level shall be restricted to 75dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.

(iv) The acoustic enclosure shall be certified to meet the emission norms.

I. Bulk Fuel Storage Tanks

(i) Bulk fuel storage shall be in accordance with the explosives norms and necessary approval shall be obtained by the contractor.

(ii) Tanks and fittings, etc shall conform to IS 803 or BS 799: Part 5The tank shall be constructed in mild steel and the fittings in materials other than:

(iii) Yellow brass, including low grade alloys of copper and zinc.

(iv) Lead and zinc.

(v) Galvanized metals.

(vi) Natural rubber.

(vii) The maximum fuel surface level below the point of entry of the vent shall not be less than 100 mm. The internal surface shall be cleaned and treated with temporary preservative, soluble in fuel oil, before shipment.

(viii) The following fittings shall be included:

(a) 600 mm diameter manhole complete with portable cover situated in the top of the tank complete with ladder to the interior.

(b) Dipstick, calibrated in litres with guide tube and striker plate.

(c) Local indication of fuel level to be given at a position where it can be easily read during fuel delivery.

(d) Filling pipe work and fittings complete with isolation valve and captive end cap. The filling point to be at the top of tank to prevent siphoning.

(e) Outlet pipe situated at the raised end of the tank not less than 150 mm above tank bottom, complete with check valve, isolating valve and end cap.

(f) Drain pipe situated at lowest point in tank complete with isolating valve and captive end cap.

(g) Inlet fittings for overflow pipe from daily service tank or tanks (where specified).

(h) Vent pipe situated at high level in the tank. The pipe shall rise continuously from the tank and terminate with an inverted `U' bend and vermin screen.

(i) External ladder for horizontal tanks more than 2 m diameter.

(j) Level sensors shall be included which are connected to Low fuel oil level.

J. Drawings

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates etc. shall be submitted along with the bid/ after award of contract as specified under " Bid/Contract Drawings" , Part 3, General Requirements, Volume-2 of Bid Documents.

6.10 UPS SYSTEM

(a) UPS shall be supplied as per Instrumentation specification. UPS shall be three phase incoming supply with breaker.

(b) All UPS shall have IGBT technology for rectifier and inverter.

(c) The system shall be complete with all mounting stands, insulators, interconnecting accessories etc all as per enclosed specifications and data sheets.

6.11 BATTERY, BATTERY CHARGER & DCDB

a) Battery, Battery Charger shall be three phase incoming supply with breaker. DC equipment shall comply with IEC 60896 including those standards referred to therein.

b) General Requirements
Following items shall be covered in the Contract:

(i) 110 V Value Regulated Lead Acid Battery (VRLA)
(ii) Float-cum-boost charger for 110 V batteries
(iii) DC distribution board.

c) All connections between battery, battery chargers and DC distribution board shall be designed for effective segregation between positive and negative leads.

d) The system shall be complete with all mounting stands, insulators, interconnecting accessories etc all as per enclosed specifications and data sheets.

A. Valve Regulated Lead Acid Battery

Design Features
Battery offered shall be Value Regulated Lead Acid Battery (VRLA) Type. The battery shall conform to the latest applicable standards specified below:
Stationary Value Regulated Lead Acid Batteries
Specification : IS 15549-2005

a) The equipment offered shall be complete with all parts that are necessary or usual for the efficient operation of the equipment, whether specifically mentioned or not.

b) The VRLA batteries shall be starved electrolyte type to allow recombining of generated oxygen internally. The battery shall be completely explosion resistant, shall tolerate freezing and shall not allow gases to escape during normal charging conditions. The battery shall not require any topping and be maintenance free.

c) All inter cell, inter modules and inter stack connectors shall be covered with heat shrunk FR/FRLS sleeves.

d) Containers, cell lids, safety vents, separators, connectors, electrolyte, shall conform to the relevant IS/IEC and safety standards. The cell containers shall conform to the safety requirements of UL 94 HB or equivalent safety standard. The safety vent shall be self resealing pressure regulating with flame arrestor. In case the batteries are proposed to be housed in a sheet metal or polymeric enclosure, the same is deemed to be included in the scope of the bidder. The enclosure for battery shall conform to the safety provisions of UL 1778 or equivalent standard.

e) The battery shall be complete with accessories and devices, including but not limited to the following:

i) Battery racks
ii) Set of intercell, inter- module and inter stack connectors as required for the complete installation.
iii) Accessories for testing and maintenance

f) Battery racks shall be constructed from steel. Metallic stands shall be painted with acid resistant paint after 2 coats of primer. The racks shall be rigid, mechanically strong, free standing type and free from warp and twist. The completed racks shall be suitable for being bolted end to end to form continuous row. Insulators shall be provided below the legs of the stands

(h) 1 set of accessories for testing and maintenance shall also be provided suitable for all the three battery banks.

i.	One	-	-3, 0, +3 volts DC voltmeter with built-in discharging resistor and suitable leads for measuring cell voltage.
iii.	Two	-	PVC aprons
iv	Two	-	Cell lifting straps
v	One set Each of	-	Terminals and cable boxes with glands for connecting cable as required. Spare connectors Spare vent plugs Spare nuts and bolts Suitable set of spanners

Drawing

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified under, "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

B. Battery Charger and D.C. Distribution Board

Applicable Standards

The battery charger and D.C. Distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern.

Basic climatic and mechanical durability tests for components for electronic and electrical equipment	: IS 900
Environmental tests for electroni andelectrical equipments	: IS 900

Metal clad base material for printed circuits for use in electronic and telecommunication equipment	:	IS: 5921
Transformers and inductors (power audio, pulse and switching) for electronic equipment	:	IS: 6297
Printed wiring boards	:	IS: 7405
Environmental requirements for semi-conductor devices and integrated circuits	:	IS: 6553
Terminals for electronic equipment	:	IS: 4007
Factory built assemblies of switchgear and control gear for voltages upto and including 1000 V AC and 1200 V DC	:	IS:8623/BS:5486 / IEC:60439
Air break switches	:	IS: 13947(Part–3) BSEN 60947- 3
Miniature circuit breakers	:	IS 8828/BSEN: 60898
HRC cartridge fuses	:	IS: 9224/BS: 88
Contactors	:	IS: 13947 (Part – 3) /BS: 775 / IEC: 60158-1
Control switches/push buttons	:	IS: 6875
Indicating instruments	:	IS: 1248/BC: 89/ EC:51
Degree of Protection	:	IS: 13947-(Part 1) /IEC: 60947-1
Climate-proofing of electrical equipment	:	BSCP: 1014
Code of practice for phosphating iron and steel	:	IS: 6005/BS: 3189
Semi-conductor converters	:	IEC: 60146
Semi-conductor rectifier equipment safety code	:	IS: 6619
Specification for copper rods and bars for Electrical purposes	:	IS: 613

Battery Charger

(a) Battery charger shall be combined float-cum-boost type.

(b) The charger shall be static type composed of silicon controlled rectifiers (SCRs) and diodes connected in three phase full wave half controlled bridge circuit.

(c) The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-star connections. The BIDDER shall ascertain if taps are required and provide adequate number of primary and secondary taps, if necessary.

(d) The float charger shall be designed for supplying :

(i) The D.C. loads specified under Sr. No. 8.19.2 of Vol II, Part-8 i.e. continuous load and short-time overload.

(ii) The trickle charging current of the battery.

(e) The boost charger shall be designed for supplying the boost charging current of the battery.

(f) If the battery and charger are to be supplied by separate contractors, the charger Contractor shall coordinate with the battery contractor regarding float /trickle boost charging current & voltages required for the battery.

(g) Battery Charger shall be provided with facility for both automatic and manual control of output voltage and current and necessary selector switch shall be provided. Contractor regarding the float/trickle and boost charging current and voltages required by the battery,

(h) Performance

(i) Float Charger

The D.C. output voltage during float charging shall be stabilised within ±1% of the set DC bus voltage. Manual control shall be used if auto mode fails.

(ii) Boost Charger

For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. After a specified number of hours (adjustable) when the rated cell voltage is reached, the charger shall be returned to float charge status.

- In case of combined float-cum-boost charger, the switching and control of high rate charge and return to float charge shall be by automatic controller/regulator. Manual control shall be used if auto-mode fails.
- During boost charging following emergency measures shall be provided:
- If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load.
- If the separate or spare float charger supplying D.C. load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes.

(i) Suitable filter Circuits shall be provided in the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of D.C Loads.

(j) The D.C System shall be unearthed.

Charger Panel and D.C. Distribution Board

(a) Battery charger panel and D.C. distribution board shall be sheet metal enclosure free standing type with cable entry from bottom.

(b) Indications, controls and output voltage setting adjustments shall be on front panel. The Contractor shall submit a scheme for alarm and trip indication lamps on the cabinet and for fault annunciation contacts paralleled for remote annunciation.

(c) The components shall be liberally rated and housed in a well ventilated sheet metal cubicle complete with input and output terminals. Louvers shall be provided for ventilation backed up by fine wire mesh so that the degree of protection shall be equal to or better than IP-42.

(d) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.

(e) All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily and marked test pins.

(f) All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.

(g) All components and modules shall be clearly and unambiguously marked and all wiring colour-coded and tagged.

(h) All power and control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required rating. The minimum sizes for control wiring will be 1.5 mm^2 and for power wiring shall be 2.5 mm^2.

(i) Ground terminals with isolating links shall be provided.

(j) Cable glands shall be provided to suit the incoming and outgoing cables.

Components/Accessories

(a) The main items are listed below. However, additional items required for completeness or to meet the specified performance or operational requirements of the charger, shall be deemed to be included in the Contractor's scope. Instead of incoming ON/OFF switches, stricker fuses and contactors, the Contractor may provide suitably rated 3 pole MCBs with overload and short circuit protection and auxiliary contacts.

(i) One (1) set - Three phase full wave half controlled bridge rectifier circuit comprising silicon controlled rectifiers and silicon diodes complete with resistor/ capacitor network for surge protection. The diodes/SCRs shall be individually protected by fuses with fuse fail indication.

(ii) One (1) Double wound, dry type, three phase suitably rated mains transformer.

(iii) One (1) set of suitably rated control transformers for electronic controller.

(iv) One (1) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilisation of ±1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, set output voltage and phase failure or voltage unbalance.

The electronic controller shall be provided with following features.

- Boost current stabilisation of ±2% with AC input variation of voltage and frequency variation of ±10% and ±5% respectively.
- Boost charge current limiter with potentiometer to adjust the setting.

(v) Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.

(vi) One (1) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.

(vii) One (1) Auto/Manual selector switch for selecting the mode of operation of the controller.

(viii) One (1) front panel mounted potentiometer for set point adjustment of output voltage in auto mode.

(ix) One (1) front panel mounted potentiometer for manual adjustment of voltage in manual mode.

(x) One (1) TP AC ON/OFF switch for float charger incoming.

(xi) One (1) set of HRC fuses complete with fuse fittings for AC input with suitable ratings and with trip indication.

(xii) One (1) set of the pilot lamps with series resistors to indicate float charger AC Mains "ON" condition.

(xiii) One (1) AC contactor with suitably rated coil and three main and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON/OFF control switch.

(xiv) One (1) set of HRC fuses complete with fuse fittings for the DC output, and with trip indication.

(xv) One (1) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the float charger output current.

(xvi) One (1) Double pole DC ON/OFF rotary switch for float charger output.

(xvii) One (1) pilot lamp with series resistor to indicate float charger DC 'ON' condition.

(xviii) Annunciation System for the following
- (a) AC Supply Failure.
- (b) Rectifier Fuse Failure.
- (c) Surge Circuit Fuse Failure.
- (d) Filter Fuse Failure.
- (e) Load Limiter Operated.
- (f) Charger Trip.
- (g) Battery on Float.
- (h) Battery on Boost.

Power Electronic Components

(a) Diode and thyristors shall be of monocrystalline type silicon, capable of continuous output at specified voltages. It shall have high power efficiency.

(b) If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly. This may be achieved with the help of chokes. Also, care should be taken to select matched pairs of rectifier heat sink units.

(c) Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.

(d) Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.

(e) The diodes or thyristor banks shall be natural air cooled.

(f) The diodes or thyristors shall be protected against overvotage due to chopping surges with the aid of snubbers (i.e. resistor-capacitor combination and Metal oxide varister). It shall be ensured that normal load currents and especially fault currents are shared equally between parallel links, within the specified limits. To achieve this, great care shall be taken to design the layout of the rectifier links to ensure equal lengths of busbars and as near as possible identical contact resistance in each current path.

Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.12 CABLING SYSTEM: HV, LV, CONTROL AND TELECOMMUNICATIONS

A. Applicable Standards

The cables shall conform to the latest applicable standards specified below.

PVC insulated cables (For voltage upto 1100 V)	:	IS: 694
HRPVC & PVC insulated cables heavy duty	:	IS: 1554
Crosslinked polyethelen insulated PVC sheathed cables	:	IS: 7098
Low frequency cables and wires with PVC insulation and sheath	:	IEC: 60189-1 & IEC-60189-2
PVC insulation and sheath of electric cables	:	IS: 5831
Polyethylene insulation and sheath for electric cables	:	IS: 6474
Conductors for insulated electric cables	:	IS: 8130
Methods of test for cables	:	IS: 10810
Specification for drums of electric cables	:	IS: 10418
Specification for PVC insulated cables for electricity supply	:	BS: 6346
Specification for PVC insulation and sheath of electric cables	:	BS: 6746

B. Features of Construction

(a) XLPE Insulated HV Power Cables :

The Cables shall be 11 KV/ 11 KV (Un earthed) grade, heavy duty, stranded aluminium Conductor, XLPE Insulated, Conductor Screening by extruded Semiconducting Compound, insulation screening through Combination of semi conducting compound and non magnetic tape(Copper tape), inner sheath over laid up cores, galvanised steel wire /strip armoured (Aluminium wire armouring for single core cables), outer sheath of extruded black PVC Compound type ST-2. Core Identification shall be by printed numerals.

(b) LT Power Cables

(i) PVC Insulated Cables:

The Cables shall be 1.1 KV Grade, heavy duty, Stranded Aluminium/ Copper Conductor, PVC Compound type A insulated, inner sheathed, galvanised steel wire /strip armoured, black PVC compound type ST1 outer sheathed.

(ii) XLPE Insulated Cables:

The Cable shall be 1.1 KV Grade, heavy duty, stranded aluminium/ Copper Conductor, XLPE insulated, inner sheathed, galvanised steel wire/ strip armoured ,extruded black PVC Compound type ST2 outer sheathed.

(c) Control Cables:

The Cables shall be 1.1 KV grade, heavy duty, stranded copper conductor, PVC Compound type A Insulated, galvanised steel wire/ strip armoured extruded PVC type ST1 outer sheathed.

(d) Telecommunication Cables:

The cables shall meet the following requirements:

(i)	Conductor	Solid, tinned, annealed copper
(ii)	Insulation	PVC insulation Type-A as per IS:5831
(iii)	Twisting	The insulated conductors shall be twisted together to form twisted pairs or quads, these shall be stranded in concentric layers to form the cable core. The cable thus formed shall be tightly lapped with outer wrapping tapes. The interstices of insulated cable core shall be completely filled with viscose compound
(iv)	Overall screening	With 0.075 mm Aluminium tape or 0.013 mm melinex tape, overlap not less than 30%
(v)	Other details	A suitable non-magnetic rip cord shall be laid longitudinally under the sheath. The armouring shall be of galvanised steel wires or galvanised single steel strip. The inner PVC sheath shall be of Type-A. The outer PVC sheath shall be of Type ST-1.

C. Cable Rating

a) The Contractor shall ensure that cable and wires associated with the distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use.

b) In assessing the rating of any cable or wire, the following factors shall be taken into account:

- Supply voltage and frequency
- Maximum voltage drop permissible
- Type and magnitude of load
- Fault level and duration related to circuit protection relays and fuses
- Circuit over current protection
- Route length and disposition of cables
- Ambient temperature
- Method of installation

c) All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 45 ^{0}C. The design current of any circuit shall exceed the full load current of the supplied device by at least 10%. Power cables shall be sized to limit the maximum voltage drop to no more than 3 %.

d) Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. The Contractor when sizing cables for the remote operation of shunt trip coils shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energisation. HV and LV cables shall be sized for a fault clearance time of 0.5 seconds for the incoming feeders and 0.16 seconds for switchboard feeders controlled by circuit breaker.

D. Cable Colours

All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.

The colour coding should be as follows:

3 Phase	Red, Yellow And Blue
Single phase or DC	Red And Black
Earth	Green/Yellow
Control	Blue (DC), Red (AC)

E. Cable Conductors

Copper conductors shall be used for cables of sizes upto 6 Sq.mm. Aluminium conductors shall be used for cables of size 10 Sq. mm and above. Cores of cross-sectional area greater than 1.5 mm^2 shall be stranded. Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm^2. Power cables shall be of a minimum cross-section of 2.5 mm^2. Internal wiring of control panels shall be of a minimum cross-section of 1.0 mm^2 flexible and stranded. Control cables shall be of a minimum cross-section 1.5 mm^2 for external use and 1.0 mm^2 for internal use.

F. Cable Numbering

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and three digit numbers.

HV power	HV-P_
LV power	P_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _
Telecommunication	T_ _ _

G. Cable Drums

Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.

The Bidder shall indicate in the offer, the maximum length for each size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within tolerance limit of ± 5% without any tolerance on total ordered quantity of each size of cable. However before winding the cables on drums. Contractor shall obtain Employer's approval for the drum lengths.

Each drum or coil of cable shall be accompanied by a certificate stating the manufacturer's name, cable size, and number of cores, length, result and date of tests as required in the Employer's Requirements. Cables manufactured more than 12 months before delivery will not be accepted. All cables shall be delivered with cable ends effectively sealed by hygroscopic scaling caps. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture. Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The Contractor shall be wholly responsible for the purchase and/or hire costs of all cable drums and for the removal of these drums from site after use.

H. Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, Test certificates etc shall be submitted along with the bid/ after award of contract as specified, " Bid/Contract Drawings" , Part 3, General Requirements, Volume-2 of Bid Documents.

6.13 CABLE CARRIER SYSTEM

A. General

The cable carrier system covers the supply of cable racks, cable trays and its supporting accessories.

B. Applicable Standards

Steel for general structural purposes	:	IS: 2062
Dimensions for hot rolled steel beam Column channel and angle sections	:	IS: 808
Code of practice for use of metal arc Welding for general construction in Mild steel	:	IS: 816
Hot deep galvanising of iron & steel	:	IS: 2629
Methods of testing uniformity of coating Of zinc coated articles	:	IS: 2633
Hot dip zinc coatings on structural	:	IS: 4759

Steel and other allied products

C. Cable Racks and Trays

(a) All cable trays, vertical raceways, cable racks and cable tray supporting structures shall be hot dip galvanised.

(b) Cable trays shall either be run in concrete trenches or run overhead supported from building steel, floor slab, cable racks, cable cum pipe racks, etc,.

(c) Vertical trays/raceways and outdoor cable trays shall be covered by removable 16 gauge GS sheet covers.

(d) The size of ladder/perforated cable trays to be supplied and installed shall be 150, 300, 450, 600 and 800 mm wide.

(e) The mounting structures/cable racks shall be fabricated from standard structural steel members (channels, plates, angles and flats).

(f) The cable racks and supports shall be painted after installation with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint

D. Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below;

(a) Fabricated Steel

Thickness less than 2 mm, but not less than 1.2 mm	340 gms/sq.m
Thickness less than 5 mm, but not less than 2 mm	460 gms/sq.m
Thickness 5 mm and over	610 gms/sq.m

(b) Fasteners

Upto nominal size M10	270 gms/sq.m
Over M10	300 gms/sq.m

Galvanising shall be carried out after all drilling; punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

6.14 LIGHTING SYSTEM

A. General Requirements

(a) Refer Part 12 - Particular Requirements, Volume-2 of Bid Documents for the requirements of lighting system.

(b) LED lighting shall be considered for indoor and outdoor lighting. Conventional lighting shall be considered subject to the requirement and approval of Employer. However general requirements of conventional lighting along with LED lighting have been described in the following sections.

(c) The Lighting system includes the following items.

(i) Lighting fixtures complete with Lamps and accessories.

(ii) Lighting system equipment

- Light control switches, receptacle units with control switch units, lighting wires, conduits and other similar items necessary to complete lighting system.

- Lighting fixture supports, street lighting poles and flood light towers.
- Main Lighting distribution board, lighting panels.
- Multi core cables for street, boundary and flood lighting.

(d) All Lighting Fixtures, luminaries shall be considered for Emergency Lighting and fed from Main Lighting Board supplied by both mains supply normally and DG Set during power failure.

(e) DC Emergency Lighting shall be provided for Control rooms of Switchyards SCADA room, Switchgear and Control room of Pump houses.

B. Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

Lighting Fixtures & Accessories

Electrical lighting fittings general and Safety requirements	:	IS: 1913/ BS: 4533
Code of practice for industrial lighting	:	IS: 6665

Calculation of co-efficient of utilisation	:	IS: 3646 (Part - III)
Industrial lighting fittings with metal Reflectors	:	IS: 1777
Decorative lighting outfits	:	IS: 5077
Dust proof electric lighting fittings	:	IS: 4012
Dust tight electric lighting fittings	:	IS: 4013
Flood lights	:	IS: 10322/BS: 4533
Luminaires for street lighting	:	IS: 10322 Part 5
Water tight electric lighting fittings	:	IS: 3553/ BS: 4533, 5225(I)
Bayonet lamp holders	:	IS:1258/BSEN 61184IEC:60061
Edision screw lamp holders	:	IS: 10276/BSEN 60238
Bi-Pin lamp holders for tubular fluorescent lamps	:	IS: 3323
Starters for fluorescent lamp	:	IS: 2215/BSEN 60155
Holders for starters for tubular fluorescent Lamps	:	IS: 3324/ BSEN 60400
Ballast for use in fluorescent lighting fitting	:	IS: 1534 (Part 1)/BSEN 60920& 60921
Transistorised ballast for fluorescent lamps	:	IS: 7027
Ballast for HP mercury vapour lamp	:	IS: 6616
Capacitors for use in fluorescent, HPMV & LP sodium vapour discharge Circuits		IS:1569/ BSEN 61048 & 61049 /IEC: 60586
Vitreous enamel reflector for tungsten Filament lamp	:	IS: 8017
Tubular fluorescent lamps	:	IS: 2418 (Part –1) /BSEN 60081 IEC: 60081
High pressure mercury vapour lamps	:	IS: 9900/BS: 3677/ IEC: 60188

Tungsten filament general electric lamps	:	IS: 418/IEC: 60432
Cast acrylic sheets for use in Luminaries	:	IS: 7569
Screwless terminal and electrical connections for lighting fittings	:	IS: 10322
High pressure sodium vapour lamps	:	IS: 9974
Emergency lighting units	:	IS: 9583
Ignition proof enclosures, dust-tight for Elect. Equipment	:	IS: 11005
Luminaires	:	IS: 10322 (Part I to V)

Lighting System Equipment

Arrangement for busbars, main connections and auxiliary wiring and marking	:	IS: 5578/ 11353/BS: 159
Enclosed distribution fuse boards and cutouts for voltages not exceeding 1000V	:	IS: 2675/ BSEN 60439
General requirements for switchgear and control gear for voltages not exceeding 1000 V	:	IS: 13947
Code of practice - installation and maintenance of switchgear	:	IS: 10118/BS: 6423 BS 6626, BS 6867
Factory built assemblies of switchgear and control gear for voltages upto and Including 1000 V AC and 1200 V DC	:	IS: 8623/BS-5486/ IEC: 60439
Miniature air break circuit breakers for AC circuits	:	IS: 8828/ BSEN 60898
HRC cartridge fuse links upto 650 V	:	IS: 9224/BS: 88/ IEC: 60269
"D" Type fuses	:	IS: 8187

Current transformers	:	IS: 2705/BS: 7626/ IEC: 60185
Voltage transformers	:	IS: 3156/BS: 7625/ IEC:60186
Direct acting electrical indicating Instruments	:	IS: 1248/BS: 89/ IEC: 60051
A.C. electricity meters	:	IS: 722/BS 5685
Electrical relays for power system protection	:	IS: 3231/BS: 142/ IEC: 60255
Switches for domestic and similar purposes	:	IS: 3854/BS: 3676
Three pin plugs and socket outlets	:	IS: 1293/BS: 546
Boxes for enclosure of electrical accessories	:	IS: 5133(1)
Rigid steel conduits for electrical wiring	:	IS: 9537/BS: 31
Accessories for rigid steel conduits for electrical wiring	:	IS: 3837/BS-31
Flexible steel conduits for electrical wiring	:	IS: 3480
Rigid non-metallic conduits for electrical Installations	:	IS: 9537/BS: 4607(2)
Fittings for rigid non-metallic conduits	:	IS: 3419/BS: 4607(2)
PVC insulated cables for working voltages upto and including 1100 V	:	IS: 694
Tubular steel poles	:	IS: 2713
Specification for copper rods and bars for electrical purposes	:	IS: 613
Code of practice for phosphating iron and steel	:	IS: 6005/ BS: 3189
Fittings for rigid steel conduits for Electrical wiring	:	IS: 2667

C. Lighting Fixtures (Luminaries)

(a) Luminaries shall be designed for continuous trouble-free operation without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and rain-proof type.

(b) The Luminaires shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.

(c) Connections between different components shall be made in such a way that they will not work loose by small vibration.

(d) For each type of Luminaires the Contractor shall furnish the utilisation factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.

(e) All Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage with the variation in supply voltage, frequency and combined voltage and frequency of ±10%, ±5% and ±10% respectively.

(f) The Luminaires and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.

(g) Fluorescent type, metal halide type luminaires shall be complete with accessories like lamps, ballasts, power factor improvement capacitors, starters, re-wirable fuse and fuse base. These shall be mounted as far as possible in the luminaire housing only. If these cannot be accommodated integral with the Luminaires then a separate metal enclosed control gear box shall be included to accommodate the control accessories together with a terminal block suitable for loop-in, loop-out connections. Outdoor type fixtures shall be provided with outdoor type weather-proof box.

(h) Fluorescent type Luminaires with more than one lamp shall be provided with capacitors connected in lead-lag circuit for correction of stroboscopic effect.

(i) Each luminaire shall have a terminal block suitable for loop-in, loop-out and T-off connection by 250/400 V, 1 core, PVC insulated copper/aluminium conductor wires upto 4 sq.mm in size. In outdoor areas the termination at the luminaire shall be suitable for 1100 V, PVC insulated, copper/aluminium conductor, armoured cables of sizes upto 6 sq.mm conductor. Terminals shall be of stud or clamp type. The internal wiring should be completed by means of standard copper wire of minimum 1 sq.mm size and terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.

(j) Mounting facility and conduit knock-outs for the luminaries shall be provided.

(k) Earthing

(i) Each luminaire shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.

(ii) Where separate control gear box is provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire.

(iii) All metal or metal enclosed parts of the luminaire/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

(l) Painting/Finish

(i) All surfaces of the Luminaire/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.

(ii) When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.

(iii) The luminaire housing shall be stove-enameled/epoxy stove-enamelled-vitreous enamelled or anodised as indicated under various types of fittings.

(iv) The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg. over 1/2" dia. mandrel.

(v) The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection.

(vi) External control gear box provided for housing accessories shall be painted or galvanised.

D. LED Lighting

(i) High Power White LEDs used in the luminaries shall have wattage greater than ONE watt.

(ii) LED shall be operated at a forward current of less than 90% of the rated current.

(iii) Colour Rendering Index (CRI) of the LEDs used in the luminaire shall be greater than 70.

(iv) The illumination of the luminaire shall be uniform without dark bands or abrupt variations and soothing to the eye.

(v) Light Uniformity Ratio (E_{min} / E_{avg}) would be > 0.4.

(vi) Luminary Body Temperature would be less than 30 ^{0}C above the ambient, even after continuous burning of Luminary for 24 Hrs.

(vii) The Luminaire works on single phase three wire system (Phase, Neutral & Earth).

(viii) The luminaire housing is made up of Corrosion free High Pressure Aluminum die cast thus confirming the luminaire to IP-68 protection and safety as per IEC 60598-1.

(ix) The Luminaire is equipped with distortion free, clear, Heat Resistant toughened, UV stabilized glass cover in the front fixed to the die cast Aluminum frame which would be fixed to the housing by means of stainless steel screws.

(x) The **minimum technical specifications for LED lighting** will be as follows:

a) Powered by the latest bright LEDs with high efficiency and meeting LM-80 standard.

b) Average rated life span of 50000 hrs.

c) LED efficacy shall be greater than 125 Lumens/watt.

d) Luminaire efficacy of at least 80 Lumens/watt.

e) Input voltage range 90-300 V.

f) Power factor > 0.9.

g) THD < 15%.

h) Ingress protection as per IP 68 for outdoor luminaries

i) Operating temperature -5°C to 50°C

j) Storage temperature -5° to 70°C

k) Humidity 10% - 100%

l) LEDs shall be operated at a forward current less than 90% of its rated current.

m) The LEDs used in the luminaire shall have minimum angle of 120 degree.

n) Colour rendering index (CRI) of the LEDs shall be greater than 70.

o) Conform to Photo Biological Safety for the LEDs as per IEC 62471.

p) Free replacement warranties of 5 years for technical defects.

E. Decorative Luminaries

Fluorescent Luminaries

(a) These luminaires shall be generally indoor type provided with cold rolled cold annealed (CRCA) sheet steel channel/rail cum reflector housing complete with all electrical control accessories mounted on it. The finish shall be stove enamelled.

(b) Decorative fluorescent type luminaires shall be either open type, provided with translucent white opal acrylic diffusers, polystyrene lens prismatic or square polystyrene louvers.

(c) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column pendant mounting or for recess mounting in false ceiling.

(d) Decorative luminaires with mirror optic reflectors shall be of the wide angle dispersion type. Where these luminaires are mounted in control rooms and computer rooms, clip-on type adjustable reflectors which can be attached onto the tube shall be provided to direct the light output in the desired direction. This is mainly to reduce reflection of the light source from TV/monitor screens.

(e) Luminaires mounted recessed in false ceiling shall be with reflector housing and spring loaded fixing arrangement for the diffuser/louver frame. It shall be possible to have access to the lamp and other accessories from below.

F. Industrial Luminaries

Fluorescent Luminaries

(a) The luminaire shall be provided with CRCA sheet steel mounting rail with reflector of minimum 20 SWG thicknesses and complete with all control accessories mounted on it. The finish shall be vitreous enamelled.

(b) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column/pendent mounting.

(c) The distribution of light shall be such that at least 80% of the total luminous flux from the luminaire shall be in the lower hemisphere.

(d) The luminous output of the luminaire with reflector shall not be less than 75% irrespective of type of reflector used.

G. Incandescent/ Mercury Vapour luminaires

Bulk Head Luminaire

(a) The luminaire shall be of robust construction, with cast aluminium/vitreous enamelled housing, heat and shock resistant prismatic or clear glass cover fixed with neoprene gaskets for sealing. For mechanical protection to the glass cover, round steel wire-guard with vitreous enamelled finish shall be provided.

(b) The luminaire shall be suitable for incandescent lamp upto 150 watts, for direct mounting to ceiling/wall/column and used for general purpose indoor lighting.

High and Medium Bay Luminaries

(a) High and medium bay luminaires shall be with cast aluminium housing, anodised aluminium mirror polished reflector canopy with eye bolt for suspension, cooling fins and glass cover.

(i) The luminaire shall be suitable for mercury vapour lamps upto 1000 watts and sodium vapour lamps upto 400 watts. The control gear accessories shall be mounted integral with the luminaire.

(ii) High bay luminaires shall be used when the mounting height is above 8 metres while medium bay luminaires shall be used when the mounting height is around 6 to 8 metres.

H. Flood Light Luminaire

General purpose flood light luminaire

(a) Flood light luminaires shall be of weather proof construction with cast aluminium housing, anodised aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust.

(b) The housing shall be supported on a cast iron base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.

(c) For focussing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.

(d) The Luminaires shall be suitable for single and dual mercury vapour or sodium vapour lamps upto 400 watts, incandescent lamps upto 1000 watts or halogen lamps upto 1000 watts. When mercury vapour or sodium vapour lamps are specified, the same shall be mounted in a separate sheet metal enclosed/cast aluminium weather proof control gear box.

(e) The luminaire shall be provided with cable gland on the canopy in down ward direction for cable connection.

(f) It shall be possible to adjust the lamp position to achieve wide beam, medium beam or narrow beam.

(g) It shall be possible to replace the lamp from the canopy without opening the front glass.

I. Outdoor Lantern Luminaries

Post top Lantern

(a) Post top lantern Luminaires shall be generally outdoor weather proof type for illumination of walkways, gate posts, gardens etc.

(b) The luminaire shall have cast aluminium spigot of 50/60 diameter finished with corrosion proof paint for mounting, opal acrylic or high density polyethylene (HDP) diffuser bowl, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.

(c) The luminaire shall be suitable upto 200 W incandescent lamp, 125 W mercury vapour lamps or 70 W sodium vapour lamp.

J. Sub-station Lantern

(a) Sub-station lantern shall be generally outdoor weather proof type for illumination of switchyard equipment.

(b) The luminaire shall have cast aluminium housing finished with corrosion proof paint, spigot for mounting on pole, prismatic glass refractor dome to give distribution of light in horizontal plane, anodised aluminium reflector to give light distribution at an angle 20 to 40 degrees, above the horizontal plane, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.

(c) The Luminaires shall be suitable upto 200 watts incandescent lamp, 125 W mercury vapour lamp or 70 W sodium vapour lamp.

K. Street Lighting Luminaries

Fluorescent Luminaries

(a) Street lighting fluorescent luminaire shall be outdoor weather proof type for illumination of secondary roads, walkways, peripheral lighting of buildings etc.

(b) The luminaire shall be of semi-cut off or non-cut off type, with CRCA sheet steel housing, vitreous enamelled, plain or corrugated clear acrylic cover, complete with integral mounted control gear, neoprene gaskets, side pipe entry or top suspension type.

(c) The luminaire shall be suitable for 1 x 40 watts or 2 x 40 watts fluorescent tubes and for mounting heights upto 4 metres.

L. Metal Halide luminaires

(a) Street metal halide luminaires shall be outdoor weather proof type for illumination of main roads, traffic islands etc.

(b) The luminaire shall be of semi-cut off with cast aluminium housing, acrylic or prismatic cover, polished aluminium reflectors, complete with integral mounted control gear, neoprene gaskets and with rear pipe entry.

(c) The luminaires shall be suitable upto 400 watts mercury or sodium vapour lamps and for mounting heights from 4 metres to 12 metres.

M. Portable Emergency Light Luminaire

(a) Emergency light of Installite luminaire shall be indoor type for providing emergency light during failure of normal AC supply.

(b) The luminaire shall be with CRCA sheet steel enclosure, complete with metallised mirror reflector, leak proof re-chargeable battery rated for two hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two metre length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaire.

(c) The luminaire shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal A.C. supply the luminaire shall pick-up automatically and on restoration of A.C. supply the luminaire shall switch off automatically.

(d) The luminaire shall be suitable for incandescent lamp upto 40 W or fluorescent lamp upto 20 W.

N. Accessories for Luminaries

Reflectors

(a) The reflectors shall be made of CRCA sheet steel/aluminium/silvered glass/chromium plated sheet copper as indicated for above mentioned luminaries.

(b) The thickness of steel/aluminium shall comply with relevant standards. Reflectors made of steel shall have vitreous enamelled finish. Aluminium used for reflectors shall be anodized/epoxy stove enamelled/mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings.

(c) Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflecting coefficient so as to ensure the overall light output specified by the Contractor.

(d) Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

O. Lamp/Starter Holders

(a) Lamp holders shall have low contact resistance, shall be resistant to wear and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal condition of shock and vibration met with under normal installation and use.

(b) Lamp holders for the fluorescent lamps shall be of the spring loaded bi-pin rotor type. Live parts of the lamps holder shall not be exposed during insertion or removal of lamp or after the lamp has been taken out. The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp is in working position.

(c) Lamp holders for incandescent, mercury vapour and sodium vapour lamps shall be of Edison Screw (E.S.) type.

(d) The starter holders shall be so designed that they are mechanically robust and free from any operational difficulties. They shall be capable of withstanding the shocks met within normal transit, installation and use.

P. Ballasts

(a) The ballasts shall be designed to have a long service life and low power loss. The ballasts shall be of the inductive, heavy duty type copper wire wound, filled with thermosetting, insulating, moisture repellent polyester compound filled under pressure or vacuum. Ballasts shall be provided with taps to set the voltage within the range of variation in supply voltage of ±10% of 240 V. End connections and taps shall be brought out to a suitable terminal block rigidly fixed to the ballast enclosure. Ballasts shall be free from hum and such of those which produce hum shall be replaced by Contractor free of cost.

(b) Ballasts shall be mounted using self locking, anti-vibration fixings and shall be easy to remove without demounting the fittings. They shall be in dust tight, non combustible enclosures.

(c) Separate ballast for each lamp shall be provided in case of multi lamp luminaires, except in the case of 2 x 20 Watts luminaires.

Starters

(a) Starters shall have bimetal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without the use of any tool. Starters shall have brass contacts and radio interference capacitors.

Capacitors

(a) The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

(b) The capacitors shall be suitable for operation at specified supply voltage conditions and shall have a value of capacitance so as to correct the power factor of their corresponding lamps circuit to the extent of 0.95 lag or better.

(c) The capacitors shall be hermetically sealed preferably in a metal enclosure to prevent seepage of impregnant and ingress of moisture.

Lamps

Lamps shall be capable of withstanding small vibrations and the connections at lead in wires and filaments/electrodes shall not break under such circumstances.

(a) Incandescent lamps

(i) General Lighting Service (GLS) lamps shall be tungsten filament incandescent type. The filament shall be coiled coil type rated for 230/250 volts, Single phase A.C.

(ii) Lamps shall be with Edison Screw type metal lamp caps to prevent pilferage.

(iii) Lamps shall be milky white for diffused, soft, glare free lighting and rated upto 100 watts.

(b) Fluorescent Lamps

(i) Fluorescent lamps shall be low pressure mercury vapour type with low wattage consumption and high efficiency and longer burning life (about 2500 hours).

(ii) Lamps shall be of white light type suitable for operation on 240 V, single phase A.C. in standard lengths of 2, 4 and 5 feet and ratings upto 65 watts.

(iii) Lamps shall be provided with features to avoid blackening of lamp ends.

Q. Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as Specified,

"Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.15 LIGHTING SYSTEM EQUIPMENT

A. Main Lighting Distribution Board and Lighting Panels (AC & DC)

(a) Constructional Features

(i) Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP 52. Outdoor panels shall in addition be completely weather-proof with a sloping canopy for protection against rain and providing a degree of protection of IP 55. The sheet steel used for frame, frame enclosures, doors, covers and partitions shall be cold rolled 2 mm thick.

(ii) All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets. For the main floor mounted distribution boards with the switch fuse units arranged in tier formation, the hinged door of each unit shall be interlocked so as to prevent opening of the door when the switch is ON and to prevent closing of the switch with the door not fully closed. However, a device for by-passing the door interlock shall be provided to enable the operation of the switch with the door open, when necessary, for examination/maintenance. For wall mounting 1-phase ways lighting panels when provided with MCBs, a hinged, latched front door shall be provided with key-locking facility and a slotted backelite sheet shall

be provided inside. Only the MCBs operating knobs or the fuse cap covers shall project out of the backelite sheet slots for safe operation and neat appearance. Incomer to lighting panels shall be provided with TPN MCB with ELCB.

(iii) All accessible live connections/metals shall be shrouded and it shall be possible to change individual fuses, switches, MCBs from the front of the boards/panels without danger of contact with live metal.

(iv) For floor mounting type distribution boards, adequately sized mounting channels shall be supplied and for wall/column/structure mounting type panels suitable mounting straps shall be provided.

(v) Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/bottom entry of cables through glands and or conduits as required.

Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.

(vi) Two earthing terminals shall be provided to suit the earthing conductor.

(vii) All sheet steel parts shall undergo rust-proofing process which should include degreasing, de-scaling and a recognised phosphating process. The steel works shall then be painted with two coats of Zinc - chromate primer and two coats of final stove-enamelled finish paint of specified colour.

(b) Busbars

(i) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.

(ii) Busbars shall be provided with at least the minimum clearances in air as per applicable standards for 500 V, 3 phase system.

(iii) Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the busbars, busbar risers/droppers and contacts does not exceed 85° C under site reference ambient temperature.

(iv) The busbars, busbar connections and busbar supports shall have sufficient strength to withstand thermal and electro-mechanical stresses of the fuse/MCB's let through/cut-off current associated with the specified short-circuit level of the system.

(v) Busbar supports shall be made from suitable insulating material such as Hylam sheets; glass reinforced moulded plastic materials, permali wood or cast resin. Separate supports

shall be provided for each phase of the busbars. If a common support is provided for all three phases, anti-tracking barriers shall be incorporated.

(vi) The neutral bus of the main 3 phase, 4 wire distribution board shall be rated not less than 50% of the phase busbars. The neutral bus of the 1 phase ways lighting panel shall be rated same as the phase busbars. The neutral bus should have sufficient terminals and detachable links for full number of single-phase outgoing lighting circuits.

B. Panels/Boards Component Equipment

(a) Switches/Miniature Circuit Breakers (MCB)

(i) Switches/MCBs shall be hand operated, air break, quick make, quick break type conforming to applicable standards.

(ii) The switch shall be protected by fuse and the MCB shall be provided with overload/short-circuit protective device for protection under overload and short-circuit conditions. The minimum breaking capacity of MCBs shall be 6 kA R.M.S. at 415 V/220 V D.C.

(iii) Switch shall have provision for locking in both fully open and closed positions. MCBs shall be provided with locking facility.

(iv) The connections between switch and fuse shall be insulated and all live connections shall be shrouded.

(b) Fuses

(i) Fuses generally shall be of the HRC cartridge fuse-link type having a certified rupturing capacity of 80 kA at 440 V. Fuses upto 63A for distribution systems of medium short circuit levels may be of HRC cartridge screw-cap, D type, having a certified rupturing capacity of not less than 46 kA at 440 V and 16 kA at 250 V D.C.

(ii) Fuses shall be provided with visible indication to show that they have operated.

(iii) Cartridge fuses shall preferably be mounted in moulded plastic carriers. If fuse-carriers are not provided, insulated fuse pulling handle shall be provided for each size of fuse for each switchboard.

(c) Indicating Instruments and Meters

(i) Whenever required, instruments and meters shall be of the flush mounting type. They shall be suitably mounted so as to provide for easy access to CTs and small wiring.

(ii) Instruments shall be of minimum 96 mm square size, shall have provision for zero adjustment outside the cover and black numerals on white dial.

(iii) Watt-hour meters shall be of direct reading electro-dynamometer type complete with cyclometer type dials and reverse running stops.

(iv) Ammeter/Voltmeter selector switches having 3 positions and off, with stay-put contacts rated 10A shall be provided when specified.

(v) Potential fuses shall be provided at the tap-off point from the busbars for the voltmeters.

(d) Instrument Transformers

(i) Current and voltage transformers shall be of the dry type, of metering accuracy class 1.0. Unless otherwise specified, it shall be the responsibility of the Contractor to

ensure that the VA burden of the instrument transformer is adequate for the meters connected to it.

(ii) Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short-circuiting and grounding the CTs at the terminal blocks.

(iii) Voltage transformers shall be provided with suitably rated primary and secondary fuses.

(e) Indicating Lamps

Indicating lamps shall be of the filament type and low watt consumption. Lamps shall be provided with series resistors.

(f) Internal Wiring

(i) Panels/boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 650/1100V grade, PVC insulated, stranded aluminium/copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.

(ii) Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.

(iii) All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded rated 500 V, of reputed make, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current; the minimum rating shall be 20 A.

(iv) Terminals for circuits with voltage exceeding 125 V shall be shrouded.

(v) Terminals shall be numbered and provided with identification strip for identification of the circuit.

(vi) Terminal blocks for C.T. secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.

C. Labels & Diagram Plate

(a) All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/panel.

(b) Labels shall be made of non-rusting metal, 3-ply lamicoid or engraved PVC.

(c) Inside the door of the 1 phase ways lighting panels a circuit diagram/description shall be fixed for reference and identification.

D. Light Control Switches

(a) Light control switches of ratings and types, i.e. decorative/industrial shall be supplied as required. The switches shall be suitable for use on 240 V, 1 Ph, 50 Hz supply.

(b) Switches shall be of flush type for mounting behind an insulated plate or incorporated with a switch plate for mounting flush with the surface of wall or switch box/suitable enclosure. The switch box/enclosure may be recessed into or mounted on a wall as per the requirement of project layouts.

(c) The size of enclosure boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be 18 gauge sheet steel galvanised. The enclosure box shall be covered with perspex/insulating cover. An enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

E. Receptacle Units

(a) Receptacle units shall consist of socket outlet with associated switch and plug. The socket outlet and switch or MCB shall be flush mounted within galvanised 18 gauge steel enclosure with insulation cover. The box may be recessed into or mounted on a wall as per requirements of project layouts.

(b) The receptacle units shall be suitable for 240 V, 1 ph - N, 50 Hz/415 V, 3 Ph - N, 50 Hz supply as required.

(c) Single phase receptacles shall be associated with a switch/MCB of same current rating and the receptacle shall become live only when the associated switch/MCB is in “ON” position.

(d) Three phase receptacles shall be associated with a TPN switch housed in the same enclosure. The receptacle shall become live only when the associated switch is in "ON" position.

(e) The plugs shall be provided with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

F. Lighting Wires

(a) The wires for wiring in lighting system shall be 250/440 V, 1/C, PVC insulated, unarmoured with stranded copper conductors.

(b) The minimum area of conductors shall be 2.5 sq.mm. for light fittings and 5A Receptacles and 4 sq.mm for receptacles rated 15 A and above.

(c) The wires shall be coaded white for phase/positive of D.C. and black for neutral/negative of D.C.

G. Conduits

(a) Rigid steel/non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation.

(b) Steel conduits shall be seamed by welding and hot dip galvanised. They shall be supplied in standard lengths of 5 m.

(c) Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.

H. Junction Boxes

(a) Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, 3 phase receptacles etc.

(b) The junction boxes shall be dust and vermin proof and shall be fabricated from 14 gauge sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof.

(c) The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, HRC fuses as required.

(d) The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one piece construction complete with terminals, insulation barriers, galvanised nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type.

(e) The boxes shall be painted with one shop coat of Red oxide zinc chromate primer followed by a finishing coat of paint.

I. Lighting Poles and Flood Light Pole Mounting

(a) Lighting poles for street lights and flood lights shall be of stepped tubular steel poles construction as per applicable standard. These poles shall be coated with bituminous preservative paint on the inside as well as embedded outside surface. Exposed outside surface shall be painted with one coat of red lead oxide primer. After completion of installation two coats of aluminium paint shall be applied.

(b) Poles for mounting flood lights shall be supplied whenever required and as per typical attached drawing. Unless otherwise specified, poles shall be painted with red lead oxide primer and two coats of aluminium paint. A steel ladder shall be provided. The length of

each step of the ladder shall be at least 300 mm and spacing between two adjacent steps not more than 300 mm.

(c) The supply of poles shall be complete with fixing bracket/necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes. The required sizes of poles and the junction box shall be as indicated in the attached drawings.

J. Drawings and Data

All Drawings, data, technical particulars ,calculations, detailed literature, catalogues ,test certificates etc shall be submitted along with the bid/ after award of contract as specified, " Bid/Contract Drawings" , Part 2, General Requirements, Volume-2 of Bid Documents.

6.16 EARTHING AND LIGHTNING PROTECTION SYSTEM

A. General

(i) The earthing and lightning protection system covers earthing conductors, earth electrodes and accessories.

(ii) Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system. Crane rails, tracks, metal pipes and conduits also shall be earthed at two points.

(iii) Steel RCC Columns, metallic stairs and rails of the building housing electrical equipment also shall be connected to nearby earthing grid conductor. Metallic sheaths/ screens and armour of multicore cables shall be earthed at both ends. Metallic sheaths and armour of single core cables shall be earthed at the switchgear end only.

(iv) Every alternate post of switchyard fence shall be connected to the earth grid by GS flat and gates by flexible lead to earthed post.

(v) Each Continuous laid length of cable tray shall be earthed at minimum two places by GS/GI Flats to earthing system, the distance between the earthing points shall not exceed 30m.

(vi) Lightning Protection System shall compromise vertical / horizontal air terminations, down conductors, test limits and earth electrodes. Air terminations, down conductors and test links shall be of galvanised steel conductors and earth connection below the ground level shall be of mild steel.

(vii) Lightning Protection System down conductors shall not be connected to other earthing conductors above the ground level.

B. Applicable Standards

The earthing and lightning protection system shall conform to the Indian Electricity rules, and the latest applicable standards indicated below:

Code of Practice for Earthing	:	IS: 3043
Code of Practice for the Protection of Building and allied structure against lightning	:	IS/IEC: 62305
Hot dip galvanising	:	IS: 2629, 2633, 4759
Structural steel	:	IS: 2062 & 808
Welding	:	IS: 816

C. Earthing Conductor

(i) The electrical installation shall where required be connected to the general mass of the earth by an earthing conductor. The material used for the earthing conductor shall be as follows:

(a) Conductors above ground shall be galvanised steel flat;

(b) Conductor buried in the ground or embedded in concrete shall be mild Steel, rod /flat.

(ii) Allowance shall be made for reduction in the cross section of the steel over the design life of the earthing system;

(iii) The earth electrode system shall comprise one or more earth electrodes, earthing network, mesh or a combination of these in order to obtain the required earth electrode resistance.

(iv) Earth electrodes where used shall be of heavy duty galvanised mild steel of not less than 40 mm NB and 3000 mm long. Where multiple electrodes are used they shall be separated by a distance of not less than the driven length.

(v) Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing tapes shall be connected. These connections shall each be housed in individual concrete inspection chamber set flush to the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked `Electrical Earth'.

(vi) All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the Employer's Representative.

(vii) Unless otherwise stated all excavation for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.

(viii) After the earth installation has been completed the Contractor shall demonstrate to the Employer's Representative that the resistance of the electrodes to earth and the

continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

(ix) Marker posts and plates shall be provided to mark the route of buried tape or conductor electrodes. The markers shall be similar to those provided for cable routes.

(x) Lightning Protection System

a) The need of lightning protection has been established by calculating the overall risk factor as per IS/IEC 62305.

b) Air termination system comprising of rods/mesh or combination of both will be provided and the methods used to determine the positioning of Air termination system will be as per IS 62305.

c) Air termination system will be connected to the earthing system by down conductors fixed along the outer surface of building. Number & layout of the down conductors will be as per IS/IEC 62305.

d) Each down comer will be terminated to a separate treated test earth electrode which in turn will be connected to station earthing system.

e) Test link will be provided in the run of each down conductor at approximately 1000 mm above ground level.

D. Main Equipotential Bonding Conductor

(i) Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.

(ii) Equipotential bonding conductors shall have the following **minimum sizes**.

a) Main Equipotential Conductors

- Main Earth Conductor buried in earth	40 mm dia. MS Rod
- 11/0.433 kV transformers, main switchboard and standby generator installation.	50 x 10 mm flat
- interconnection to lightning protection system	50 x 10 mm flat
interconnection to MCC s	50 x 10 mm flat

b) Equipotential Conductors

- interconnection to CP s	25 x 3 mm flat
- power factor correction capacitor panel	25 x 3 mm flat
- local push buttons	14 SWG wire
- lighting distribution board	4 SWG wire
- lighting and receptacle system	12 SWG wire
- outdoor street lighting	8 SWG wire
- ladder rack and cable tray at suitable points	25 x 3 mm flat
- hand rails and metallic structures	25 x 3 mm flat
- building reinforcement	25 x 3 mm flat
- incoming and outgoing process services	25 x 3 mm flat
- steel structures comprising storage tanks, platform, crane rails, air handling ductwork systems etc.	25 x 3 mm flat mezzanine
- LV Motors	
- up to 10 kW	8 SWG wire
- 10 to 20 kW	4 SWG wire
- 20 to 50 kW	25 x 3 mm flat
- Earth electrode	40mm dia 3000 mm long heavy Duty G.I. pipe electrode

Notes:

1 Equipotential conductors shall interconnect between the device to be bonded and the main equipotential conductor.

2 Connections to building structural steelwork or concrete reinforcement shall be made by a bolted connection to a tag welded to the steelwork or reinforcement bars. Unless otherwise specified at least two connections shall be made to the steelwork and reinforcement bars at the perimeter of each building at diagonally opposite locations.

E. Circuit Protective Conductors

(i) An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:

- a separate core within a multicore cable;
- a separate conductor installed within a conduit or trunking. Steel conduit or trunking shall not be used as a circuit protective conductor;
- The metal sheath of an armoured cable. The sheath shall be bonded to the metalwork of the apparatus and to the apparatus earth bar if any;
- the copper sheath of a mineral insulated copper sheathed cable;
- an independent earthing conductor MS or GS conductor run adjacent to the circuit it protects.

(ii) Circuit protective conductors associated with the main circuits supplying switchboards and large electrical loads, i.e. motors in excess of 75 kW shall form a separate core of a multicore cable feeding the device or shall be an independent insulated copper conductor run adjacent to the supply cable. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel or fortuitous earth paths.

(iii) The armouring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.

(iv) Where the cable armouring or sheath is used as the circuit protective conductor it shall be securely bonded at both ends to the metalwork of the apparatus and to an earth bar. Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and should the design of such items of apparatus not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths/armour to any piece of apparatus fitted with a special earth terminal should the earth connection for the termination gland be inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

(v) Instrumentation Earth

An instrumentation earth bus, if required shall be provided in each control panel. This shall comprise a copper flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the instrument earth. If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again

with a single earth connection to the same point as before. In this fashion all instrument earths shall be connected radially from the same earth point.

(vi) The earth pit for instrumentation system shall be separate. Electric earth pits shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

(vii) SPDs associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturers recommendations.

F. Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

a) Fabricated Steel

Thickness less than 2 mm, But not less than 1.2 mm	340 gms/sq.m
Thickness less than 5 mm, but not less than 2 mm	460 gms/sq. M
Thickness 5 mm and over	610 gm / sq.m

b) Fasteners

Upto nominal size M10	270 gms/sq.m
Over M10	300 gms/sq.m

Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

6.17 FIRE DETECTION AND ALARM SYSTEM

(a) Fire alarm system shall be provided for notification of fire alarm, supervisory and trouble condition and to control fire safety functions.

(b) The design requirements are defined in the specifications. as part of design engineering, fire alarm scheme based on requirements of NFPA 72, National Fire Alarm Code (2002 edition) shall be developed for the areas given in the tender drawings.

(c) The Fire Alarm and Detection system shall comply with NFPA 72 & IS 2189 for all applications.

(d) The design is typically provided in compliance with the model building codes having jurisdiction in that area. NFPA 72, 2000 edition: The National fire Alarm code is usually used for the installation methods, testing and maintenance.

(e) Connection conditions from relevant regional authorities & institutions shall be maintained (Police & Fire, emergency services).

a) National Building code of India (BIS)
b) BIS: Bureau of Indian standard (IS: 2189)
c) NFPA: National Fire Protection Association
d) IEC: International Electro technical commission
e) NEC: National Electric Code
f) NEMA: National Electrical Manufacturer's Association
g) NBC: National Building Code

(f) Fire Alarm system shall be designed to provide continuous surveillance against fire in the areas covered by the system under all conditions.

(g) The Fire alarm control panel, detectors and other related devices used in the system shall conform to international Standards UL / LPCB / FM.

(h) Fire Alarm Control Panel (FACP):

(a) The FACP shall be of microprocessor based design having the required number of outgoing loops (Minimum 8 loops per panel) to connect addressable type detectors and devices.

(b) Microprocessor based Control unit(Panel) at each local Fire alarm system shall have following Features:

- The Panel shall confirm to FM /UL listed.
- Each detector / device that is connected on the loop shall be identified by a unique address that shall be assigned to each device. This address shall indicate the individual device address as well as the address of the loop to which it is connected.
- Check the status of the system at definite pre set intervals and give warning in case of system faults like open circuit, short circuit, dirty detector, removal of detector or any other faults.
- In case of fire the panel shall give audio as well as alphanumeric display. From the display the zone and location of fire should be readily identified.
- Power to detection devices and notification appliances shall be supplied from FACP.
- Characteristics of Main Display Unit of each FACP:

i. General display current date, time, last event, number of alarms, priority wise alarm list, and any other applicable information shall be displayed on each FACP.

ii. Automatically display system messages, alarms. Vital information to operators concerning a fire situation.

iii. Fire progression & evacuation details.

(c) Power Supply Requirement for FACP

Power Supply requirement for FACP (Fire Alarm & Control Panel). Primary supply - 230VAC, 50Hz.

1) Back-up/secondary supply - sealed, lead-acid batteries.

i. FDAS panel shall be backed up with its built in battery & battery charger. Battery shall have capacity to back up complete operation for 48 hrs. Battery shall have sufficient capacity to power the fire alarm system for not less than 48 hours plus 30 minutes of alarm to an end voltage of 1.14volts per cell, upon a normal AC power failure.

ii. The power supply unit shall accept 230 V AC mains power. The power supply unit shall supply DC power to all the interface cards/modules within the FAP as well as to all the devices wired on all the FAP loops.

iii. Simply monitoring the battery voltage level shall not be accepted as battery supervision.

iv. Batteries shall be rechargeable, sealed maintenance-free type. Battery capacity shall be sized to provide backup power to the FAP for supervision and alarm.

2) Both mains failure as well as low battery level troubles shall be annunciated by the FAP.

3) Battery Charger:

i. The power supply shall supervise the standby batteries and provide a dual rate constant current battery charger featuring automatic temperature compensation. It shall be completely automatic, constant current charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 230V, 50 Hz power source.

ii. It shall have protection to prevent discharge through the charger.

iii. It shall have protection for overloads and short circuits on both AC and DC sides. A trouble condition shall actuate the charger signal.

iv. Charger shall have automatic AC line voltage regulation, automatic Current-limiting features, and adjustable voltage controls.

(i) Manual Call Points (MCPs) shall be mounted at exit points of all areas (at operating height of 1.2 M) with operating instruction (IN CASE OF FIRE BREAK GLASS") printed on the facia housed in a suitable housing to avoid inadvertent operation.

(j) The FAP shall have the facility to monitor & process all the input signals received and also have the facility to control all the output signals connected to various devices in the field through any of the loop interface modules/cards.

(k) Fire fighting system shall contain but not to limited to, the items listed below – i)

(i) Portable fire extinguishers

ii) Nitrogen injection fire prevention method for transformer

iii) Sand & Water Bucket

6.18 PREFERRED MAKES/ MANUFACTURERS:

The list of preferred Makes/ Manufacturers is given below:

SL NO	DESCRIPTION	MANUFACTURER/MAKE
1.	Power transformers	M/s ABB M/s BHEL M/s Siemens M/s Areva T&D M/s Crompton Greaves Limited
2.	Auxiliary transformers	M/s ABB M/s BHEL M/s Siemens M/s Areva T&D M/s Crompton Greaves Limited M/S Volt Amp M/S Bharat Bijlee M/s Kirloskar Electric
3.	11 kV Metal enclosed switchgears /MCC	M/s Siemens M/s ABB M/s Crompton Greaves Limited M/s Areva M/s BHEL

SL NO	DESCRIPTION	MANUFACTURER/MAKE
4.	HV Vacuum Circuit Breaker	M/s Siemens M/s ABB M/s Crompton Greaves Limited M/s Areva M/s BHEL
5.	Protective Relays	M/s ABB M/s Schneider Electric M/s L&T M/s GE M/s Siemens M/s Areva T&D
6.	Neutral earthing resistors	M/s Bharatia Cutler Hammer (I). Ltd M/s Crompton Greaves Limited M/s Indcoil Mfg Company Limited
7.	H.T & L.T Current Transformers	M/s ABB M/s Areva T&D M/s CGL M/s BHEL
8.	11 kV capacitor and panel	M/s BHEL M/s ABB, M/s CG Power Systems M/s Universal Cables
9.	LV Switchgears /MCC	M/s Schneider Electric M/s ABB M/s. Siemens M/s GE M/s L&T
10.	Lighting Fixtures and Accessories	M/s Philips M/s ABB M/s Crompton Greaves Limited M/s Wipro M/s Bajaj Electricals
11.	L.T Power Capacitors	M/s BHEL M/s ABB, M/s CG Power Systems M/s Universal Cables

SL NO	DESCRIPTION	MANUFACTURER/MAKE
12.	Alternators for DG Sets	M/s Kirloskar Electric M/s CGL M/s BHEL M/s Jyoti M/s Stomford
13.	Cables	M/s Universal Cables M/s Polycab M/s Havell‟s
14.	Battery	M/s Exide Industries M/s AMCO M/s HBL-NIFE
16.	Battery Chargers	M/s Universal Instruments M/s Amararaja M/s Chabhi Electricals M/s HBL-NIFE M/s Caldyne
17.	Cable Termination Kits	M/s Mahindra Engg and Chemical Products M/s REPL M/s Raychem

Note:

Other Makes, if offered, are subject to Specific Approval by the Employer/ Employer's Representative based on the Submission of the following documents by the bidder:

(i) Copies of Type Test Certificate for the items offered.

(ii) List of Clients to whom already the items have been supplied along with the year of Supply and Value of Orders

(iii) Copies of Performance Certificate from the User's for the items.

(iv) Copy of latest ISO Certification for the Manufacturer

(v) Details of Manufacturing Facilities

(vi) Turn Over of the Manufacturer

(vii) Copies of Approval for the items from reputed Consultants.

End of Part-6

PART 7

GENERAL REQUIREMENTS –

INSTRUMENTATION CONTROL AND AUTOMATION

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PART 7

GENERAL REQUIREMENTS – INSTRUMENTATION CONTROL AND AUTOMATION

7.1 Introduction

This part covers the general requirements for the design, supply, installation, inspection and testing of the instrumentation, Control and Automation (PLC based SCADA system inclusive of wired and wireless communication system) and associated plant and materials.

7.2 Reference Standards

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

BS 89-2:1990, EN 60051-2:1989, IEC 60051-2:1984	Direct acting indicating analogue electrical measuring Instruments and their accessories.
BS 1042 (Various)	Measurement of fluid flow in closed conduits.
BS 1646-1:1979, ISO 3511/I-1977	Symbolic representation for process measurement control Functions and instrumentation. Basic requirements
BS EN 837-1:1998	Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
BS EN 60751:1996, IEC 60751:1983	Industrial platinum resistance thermometer sensors
BS 3680 (Various)	Measurement of liquid flow in open channels.
BS 3693:1992	Recommendations for design of scales and indexes on analogue indicating instruments
BS EN 60770-1:1999, IEC 60770-1:1999	Transmitters for use in industrial-process control systems. Methods for performance evaluation
BS 4675-2:1978, ISO 2954-1975	Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity
BS EN 60584-1:1996, IEC 60584-1:1995	Thermocouples. Reference tables
BS 5308 (Various)	Instrumentation cables
BS EN 60529:1992	Specification for degrees of protection provided by enclosures (IP code)
BS ISO 11631:1998	Measurement of fluid flow. Methods of specifying flowmeter performance

BS 5863-1:1984, IEC 60381-1:1982	Analogue signals for process control systems. Specification for direct current signals
BS 5863-2:1980, IEC 60381-2:1978	Analogue signals for process control systems. Specification for direct voltage signals
BS EN 60654-1:1993, IEC 60654-1:1993	Industrial-process measurement and control equipment. Operating conditions. Climatic conditions
BS 6739:1986	Code of practice for instrumentation in process control systems: installation design and practice
BS EN 60073:2002	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators
BS 1553 (Various)	Specification for graphical symbols for general engineering
ISA-5.1-1984 - (R1992)	Instrumentation Symbols and Identification
ISA-5.4-1991	Instrument Loop Diagrams
ANSI/ISA-7.0.01-1996	Quality Standard for Instrument Air
ANSI/ISA-18.1-1979 - (R1992)	Annunciator Sequences and Specifications
ISA-26-1968	Dynamic Response Testing of Process Control Instrumentation
ISA-37.1-1975 - (R1982)	Electrical Transducer Nomenclature and Terminology
ISA-37.3-1982 - (R1995)	Specifications and Tests for Strain Gage Pressure Transducers
ANSI/ISA-50.00.01-1975 (R2002)	Compatibility of Analog Signals for Electronic Industrial Process Instruments
ANSI/ISA-51.1-1979 - (R1993)	Process Instrumentation Terminology
ISO 9000 and 09004	Quality Systems
IEEE 60587	Power Supply Surge Protection
IEC 61131-3	Programming Languages for Programmable Controllers.
IEC 61158-2	Communication Protocols
ISO 9075 (BS 6964)	Structured Query Language (SQL)
BS 5515	Documentation of Computer Based Systems
BS 7165	Recommendation for Achievement of Quality in Software
BS EN 50081	Electromagnetic Compatibility
ISO 3511	Process measurement control functions - instrumentation symbolic representation.
ISO-OSI	7 Layer Communication Model
IEC-8705101	Modbus Protocol Conversion
IEEE 472-1974	Surge protection.
NEMA	National Electrical Manufacturers Association

7.3 Statement of Compliance

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during FDS submission once the contract has been awarded.

All standards which the Contractor intends to use but which are not part of the above Standards or other listed Reference Standards, shall be submitted to the Engineer for consent before any design against that standard proceeds.

7.4 Qualification Criteria for Instrumentation Manufacturer, Automation System Manufacturer, and Automation System Integrator

ISO 9001 or above accreditation shall be a minimum qualification for all Instrumentation and/or Automation System Manufacturers and all Automation System Integrators (System Integrators).

The complete Instrumentation, Control, and Automation works in this contract shall be executed by a single System Integrator with a minimum of 5 years of experience in automation projects. The System Integrator shall demonstrate capability and resources for integrating/interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution.

The System Integrator shall submit evidence that they employ in excess of 25 personnel, including no less than 15 technical staff to include engineers, programmers, and field technicians. Qualifications and license details for a minimum of three professional engineers in the direct employ of the System Integrator, as well as resumes of all personnel assigned to this contract shall be submitted as part of the Contractor‘s technical bid.

The System Integrator shall be an authorized system integrator for the Automation System Manufacturer(s). Verification certificates shall be submitted directly from the manufacturer(s) of the Automation System. In addition, references shall be provided with the Contractor‘s technical bid for a minimum of five (5) locations where the proposed manufacturer‘s Automation System has been successfully installed by the proposed System Integrator within five (5) years prior to the bid date and has been successfully operating for at least two (2) years immediately prior to the bid date. References shall include name, address, and telephone number for the appropriate contact person.

The Instrumentation Manufacturer(s) shall have minimum 15 years of experience in India in the field of instrument supply and service and shall have a local service centre in Bengaluru.

All hardware and software proposed shall have been successfully used in a similar sewage treatment plant application for a period of at least five (5) years and be from established and reputable suppliers.

7.5 Documents to be submitted during Bid Submission

1. Include a complete Table of Conformance to each and every reference standards or part of the specifications. Use a chart format with specification part identified, indicate whether each part is in compliance, a deviation or an exception to the specific part. If an exception or deviation, include a narrative description as to how the deviation or exception can benefit the end-user of the system over that item specified.

2. Provide a block diagram of the proposed system showing all major components and their interconnections and interrelationships. Label each diagram and indicate all external power and communications interfaces.

3. Provide a written overview of the proposed SCADA system, instrumentation system describing the principal functions and capabilities of the system‘s PC, PLC‘s, system communications and general system capabilities (maximum number of network nodes, PLC‘s and I/O points, communication protocols available, etc.).

4. Provide an equipment list with descriptive literature for the proposed system. Included on the list shall be all major hardware items. List shall include as a minimum, the manufacturer, the quantity provided, and model numbers for each. Technical schedules for Instruments, PLC & SCADA shall be duly filled in with relevant details.

5. Provide an operating system and software applications list with descriptive literature for the proposed system. Include all major software items, supplier name, quantity, and model numbers. Indicate whether any proposed software is proprietary and would not be turned over to the owner. (No proprietary software shall be accepted).

6. Information is required for:

    a. Name and version of the proposed PC‘s operating system.

    b. Name and version of the proposed computer operator graphical user interface software package (SCADA).

    c. Name and version of the PLC on-line/off-line programming software for all controllers

    d. Name and version of any required communications software, firmware, etc.

    e. Name and version of the specified report application software.

    f. Name and version of the specified maintenance application software if any.

    g. Describe how system data points are linked from the system database into various applications such as reporting or maintenance. If via DDE (Dynamic Data

Exchange) describe specifically the steps required to import data automatically and on-line into the proposed software applications.

h. Briefly describe the required procedure for configuration and/or programming of the proposed system to add a simple remote PLC and additional I/O‘s to the system in the future. Describe in detail, specifically how communications are programmed for the future remote PLC and the necessary changes required at the main controller.
i. Provide a description of any non-resident software required to program, troubleshoot or diagnose any devices in the system.

j. Provide a tentative construction schedule for completion of the project within the specified Contract period. Indicate the following activities with milestones: Mobilization, radio communications licensing, submittal preparation, submittal review, equipment procurement, equipment assembly, system configuration and programming, factory testing, system delivery, system installation, start up, field testing and training, and post acceptance routine service intervals.

k. Describe the system supplier‘s provisions for service, technical assistance and re-placement parts for the proposed system. Include the system supplier‘s 1-800-toll free number. Identify with resumes, all personnel who will be providing technical support services for the project after it is accepted.

The Contractor shall provide the above required details/documents during the bid submission. Failure to submit even one of the above will be treated as a non-responsive bid and lead to technical rejection of the bid. Contractor shall note the importance of this obligation.

7.5.1 General Submissions

The Contractor shall make submissions to the Engineer of all design drawings, schedules and complete documentation on spare parts relating to instrumentation, control and Automation equipment and systems provided under this Contract.

These submissions shall include, where relevant, the following:

7.5.2 Functional design specification

The Contractor shall submit a complete Functional Design Specification (FDS) for approval by the Engineer within 3 months of the award of contract. This document shall serve as the primary mechanism by which the Engineer may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item. Proposed SCADA screens shall form an integral part of FDS submissions.

The format of the program details may be chosen by the Contract, however it is suggested that this format be chosen to satisfy the requirements of the software design documentation, if applicable, as described elsewhere.

The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence.

The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.

The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

The Contractor shall submit and obtain approval of the FDS from the Engineer before beginning the detailed control system design. The contractor should take note of the importance of this obligation.

7.5.3 Drawings and schedules

(a) Process and instrumentation diagram which shall comply with BS 1646 and BS 1553/equivalent ISA standard.
(b) General arrangement drawings of field-mounted instruments showing installation details.
(c) General arrangement drawings of instrument and control panels fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
(d) Layout drawings of panel fascias showing instruments, controls and details of all labels.
(e) Layout drawings of panel interior showing equipment, terminal blocks and cable ways.
(f) Annunciator arrangement and engraving details.
(g) Internal circuit and wiring diagrams for instrument and control panels.
(h) Schematic control diagrams.
(i) Instrument loop diagrams.
(j) Instrument wiring and piping diagrams.
(k) Interconnection wiring diagrams.
(l) Cable block diagrams, drawings and schedules.

(m) Instrument system and panel power distribution diagrams.
(n) Programmable-device functional design specifications which shall include hardware details, logic flow charts, ladder diagrams and program listings.
(o) Schedules of inputs to and outputs from programmable controllers and telemetry outstations.
(p) Labelling schedules.
(q) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.

All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels and the like and for the complete understanding of the operation, maintenance and extension of the system including any required for the Purchaser to dismantle, repair, maintain, modify or extend the Plant.

7.5.4 Data and calculations

(a) Manufacturers'catalogues and data sheets.
(b) Calculations to support control system design.
(c) Specification for protective coatings and painting.

7.5.5 Certificates

(a) Manufacturers'works tests.
(b) Pre-installation checks.
(c) Pressure-testing schedules.
(d) Instrument loop test check sheets.
(e) Installed instrument performance tests.
(f) System tests.
(g) Statutory certificates of compliance (such as hazardous area equipment).

7.5.6 Operation and maintenance instructions

(a) Composite manual describing the functional and operation of each piece of equipment.
(b) Composite manual for testing and servicing every system and individual item.

7.6 Design

7.6.1 Basic Features

Instrumentation, Control, Automation system shall be designed, manufactured and installed to achieve the following basic requirements:

- to maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance;
- to suit the abilities of the staff who will:

- use the systems;
- service the systems;

- to measure, indicate, process, store and control the relevant parameters, as specified;
- to give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of ‗operations and maintenance' personnel and plant and to store and collate the data, as required;
- to derive, present and utilize, as required, such additional data as required to facilitate:
  - the most efficient operation of the plant;
  - the routine maintenance of the plant

7.6.2 Design Requirements for Instrumentation, Control and Automation Systems

The instrumentation, control, automation installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years, unless otherwise approved by the Engineer.

7.7 Site Conditions

A. Temperature and Humidity Range. The equipment shall be installed in an environment having a temperature range of 0 °C to 55 °C and a maximum relative humidity of 100 % (non condensing). The Contractor shall use, where required, fans, heaters, and air conditioning units to maintain a correct working temperature for his equipment. All Parts of the equipment shall be constructed of materials or treated to prevent the formation of mould, fungus or any corrosion over the temperature and relative humidity ranges specified.

B. EMI/RFI Noise Immunity. The equipment to be provided shall be adequately protected against interference from the use of radio transmitters, at any point external to the equipment housings and no malfunction of the equipment shall result from this cause. Responsibility for the correct and reliable operation of the equipment shall rest with the Contractor, who must ensure that the equipment is adequately protected against the ingress of radiated, mains-borne signal-borne interference.

C. Generated Interference. The Contractor shall ensure that the computer, instrumentation and communications equipment conforms to BS EN 50081-1or equivalent Indian Standard for noise emissions.

D. Coordination. The Contractor shall check with other trades to ensure that equipment and material can be installed in space provided. Provide other trades with information necessary for them to execute their work. Details on Drawings, which are specific regarding dimensions and locations, are for information purposes. Coordinate with other trades to ensure work can be installed as indicated.

E. Sequencing. The Contractor shall make applications to the local telecommunications Service Provider for provision of communications and coordinate with the sub-contractor responsible for installation of power supply services under this contract. Applications shall be made in time to ensure services are available for installation and commissioning of the telemetry equipment.

7.8 Enclosure/Panel Details

7.8.1 Enclosures and mounting boards

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment.

All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure and board shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear. Enclosures mounted inside buildings shall have a minimum rating of protection to IP 54.

Enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to IP 65 and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather and direct sunlight. Also, when enclosures for use outside buildings are located where exposure to direct sunlight will give rise to high top-panel surface temperatures such that the internal temperature rises above the manufacturer‘s recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure. The sun shield shall prevent direct sunlight from reaching the instrumentation for the full day throughout the year, and shall have louvered ventilation.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

Enclosures shall have hinged access doors, fitted with recessed lockable handles.

Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus.

Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere.

Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

7.8.2 Panel design and construction

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels.

The design and dimensions of control consoles and desks shall be determined according to their intended function and shall be in accordance with the requirements of the Specification. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level.

Controls, switches and push-buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings.

The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance.

Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments, accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

7.8.3 Panels - Major

Panels shall be constructed generally as specified in the preceding clause. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.
Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance.

Flanged edges shall be straight and smooth.

Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of center of gravity and method of fabrication, with the following minimum thickness:

- instrument bearing surfaces, gland plates and pneumatic distribution plates, 3mm;
- internal mounting plates, 3mm;
- doors, covers and filler panels, 2mm.

No design involving the use of externally-visible assembly or fixing bolts and screws or any design resulting in dust or water-collecting crevices will be accepted.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors.

Each panel shall be mounted on a self-draining base frame fabricated from 150mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the main steelwork of the panel.

A chequer-plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable.

Sufficient removable un-drilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface mounted enclosure may form a part of the base or top.

Panels containing instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.

All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination.

Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvres to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air circulation louvres shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces.

If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections.

All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection.

Provision shall be made for safe and easy handling during transit and installation.

If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cut-outs with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided.

Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

7.8.4 Panels - Minor

Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be classed as minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause.

Panels shall be fabricated from sheet steel or other approved material less than 2.5mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface-mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed, issued to the Purchaser and subsequently replaced with bolts after installation.

Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.

The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

(a) **Local control panel (LCP):-** Local Control Panel shall be provided for each Motor near the drive and shall be Interconnected with MCC. The Local Control Panel shall have the following Provisions.

- 3 Push buttons "START / STOP / EMERGENCY STOP"
- Start / Stop push button operates when the switch on LCP is in "MANUAL" position.
- Emergency Stop push button operates irrespective of the position of the switch.

When the selector switch on LCP is in "LOCAL" position, the motor will be operated by push buttons on LCP and will take into account only the specific fail-safe controls of the equipment (electrical protections, low level for a pump). When the selector switch on LCP is in "REMOTE" position the drive will be operated from PLC.

➢ **Motorized Valves for STP's (Field Type):-**

Motorized valves will use fully integrated control Actuator. The actuator comes with integrated:

- Selector switch "Remote" / "Local "
- P.B's for: OPEN / CLOSE/ STOP.

Note:- Necessary Field Indicating devices (Where-ever process Interlocks are applicable) and LED's (Motor's, Actuator's etc., of feedback Indications) shall be provided on LCP's for Manual control operations.

7.8.5 Panels – Composite

In situations where space limitations preclude the use of separate instrumentation, control and automation (ICA) and switchgear panels and, at the sole discretion of the Engineer, ICA equipment may be combined within a single enclosure subject to the following conditions:

- The observance of all other clauses herein relating to enclosures, mounting boards and minor panels;
- The written assurance of each supplier of ICA equipment that the proximity of the switchgear will have no detrimental effect on the life or performance of any ICA component;
- The total segregation of ICA equipment and switchgear including the glanding and termination facilities;
- The absence of any voltage exceeding 250vac or 50vdc from any compartment containing ICA equipment;
- The use of the full height of the panel (excluding the bus bar chamber and Cable space) for any ICA equipment compartment.

7.8.6 Panel protection

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition.

All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic molded insulating material of an approved make. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier. Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage.

Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type.

At least 10%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainders are unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level.

7.8.7 Panel isolation

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the 'off' position. The 'on 'and 'off' positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position.

Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be live when the power supply isolators are in the 'off' position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labeled with suitable warning notices.

Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the 'free' plug and a socket mounted adjacent to the device.

The power supply connector shall be a socket.

7.8.8 Panel terminal blocks

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analysers, resistance thermometers, retransmitting slide-wires and thermocouples may be terminated at their appropriate instruments.

A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty.

Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for _Panel internal wiring‘ which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal moldings shall be in melamine to BS 1322, polyamide or equivalent. Terminal rails shall be hot-dip galvanised. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer. Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the Klippon type SAKC or equivalent which permit the connection of a test milliammeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or two internal wires shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable.

Each row of terminal blocks shall contain at least 25% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit.
Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalised where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimise the risk of accidental contact.

7.8.9 Panel internal wiring

Panel circuits shall be segregated into the following categories:

Group 1: Power control and very-high-level signal wiring (above 50V):

1.1 ac power supplies;

1.2 dc power supplies;

1.3 ac current signals above 50mA (such as CT circuits);

1.4 ac voltage and control signals above 50V (such as PT circuits).

Group 2: High-level signal wiring (6V to 50Vdc):

2.1 signals from conventional electronic transmitters and controllers (such as digital or 4mA to 20mA);

2.2 circuits to alarm annunciators and other solid-state devices

2.3 digital signals;

2.4 emergency shut-down and tripping circuits;

2.5 on/off control circuits;

2.6 intrinsically safe circuits;

Group 3: Low-level signal wiring (5V dc and below):

3.1 signals from thermocouples;
3.2 signals from resistance thermometers and re-transmitting slide-wires;
3.3 signals from analytical equipment and strain gauges.

For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:
(a) The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel;
(b) The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.
Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm^2 minimum copper conductor with HPDE or PVC-insulated cable of adequate grade and rating.

Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm^2 minimum copper conductor with 250V grade, PVC-insulated cable of adequate grade and rating.

Wiring sheath colors shall be black for ac circuits, and grey for dc circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals.

All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non-corrodible flexible tubing. Not more than **75%** of the capacity of trunking, ducts, looming, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded.

Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

7.8.10 Panel wiring identification and termination

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a color coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally.
The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling.

Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

7.8.11 Panel Earthing

A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armouring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass

terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals.

In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s).

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

SPD s associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer‘s recommendations.

7.8.12 Panel lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three metres of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

7.8.13 Panel ventilation

Each panel shall be provided with ventilation fans as required to ensure that equipment within the panel is maintained within manufacturer‘s recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably-labeled enclosed switch mounted internally in an accessible position.

Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

7.8.14 Panel labels

All control gear shall be fully labeled with the KKS code identifying the equipment designation/function, all external and internal components, all rating data, detailed equipment operating data and for danger and hazard warning.

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as detailed in the Specification. Wording shall be clear, concise and unambiguous and shall be subject to review by the Engineer before manufacture. Each label shall be permanently secured to the surface near the item to which it refers. Externally-fitted labels shall be of Perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black.

The rear surface of each Perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Laminated materials or rear-engraved and filled plastic shall be used for internally fitted labels, which shall be white with engraved black letters.

Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

- To describe or identify circuits or circuit components;
- To identify dc polarity;
- To warn or remind about dangerous or potentially-dangerous circumstances;
- Wherever elsewhere specified.

Unless otherwise specified, all engraving shall be in plain block letters, 4mm high. The

minimum practicable number of different sizes shall be used.

Manufacturers' nameplates shall not be fitted on panel external surfaces.

7.8.15 Panel finish

For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates, corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved anti-rusting priming coat and the final coat shall be an opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch-priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish to be advised by the Engineer. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer.

The overall dry film thickness (DFT) shall be between 85 and 120 microns.

Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanised or otherwise finished to an approved standard.

7.9 Instruments and ancillaries

7.9.1 General

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and manufacture throughout the Works in order to facilitate maintenance and the stocking of spare parts.

All equipment shall be fully tropicalised and suitable for the worst environmental operating conditions. Panel-mounted instruments shall be of the electrically operated flush mounted type and shall have damp-proof and dust-proof cases.

Instruments mounted outside instrument panels shall have weatherproof and dustproof cases. Instrument cases shall be of corrosion-resistant material or finish.

Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any working part. Moving parts and contacts shall be adequately protected from the ingress of dust. Where applicable instruments shall be easily withdrawable from its housing for maintenance without interrupting its signal.

Unless otherwise specified, instruments shall be finished in the manufacturer‘s standard colour. Instrument dials shall be of such material that no peeling or discolouration will take place with age under tropical conditions.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 150mm except where forming part of standard instruments and accessories such as air-sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal-transmission systems shall be in accordance with BS 5863: Part 1 or equivalent and shall use a signal of digital or 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the performance requirements specified in the appropriate part of BS EN 60770-1or equivalent. For the important and critical processes the transmitting

devices, such as pressure, temperature and level gauges, shall have a reference gauge installed locally for easy reference for the operation and maintenance staff.
The transmitters shall be provided with LCD meters.

Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously. Unless provided with unalterable factory configured ranges, measuring instruments shall have zero and span adjustment.

Field mounted instruments shall be mounted such that they are easily viewable and easily accessible for maintenance.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance.

Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points.

In order that maintenance and inspection may be carried out safely and conveniently instruments mounted in elevated and open work areas shall be provided with safety ladders and a sufficiently sized working platform with sun shading.

7.9.2 Indicating Instruments and Meters

General
All instruments and meters shall be flush mounted and generally of the same pattern and appearance throughout and those which perform similar duties shall be of uniform type and manufacture.

Indicating instruments shall be fitted with an externally accessible zero adjuster. They shall have no parallax error and their normal maximum reading shall be approximately 60% full scale deflection.

Ammeters in motor starter circuits shall be capable of withstanding the starting current and shall have a compressed overload scale. The ammeter shall have an adjustable and sealable red pointer set to indicate normal full load current. The ammeter physical size shall be in keeping with the size of the starter concerned. The minimum size to be used is 0.25 DIN.

Indicating instruments shall comply with IS 1248, BS 89 or IEC 60051 and shall be of industrial grade accuracy.

(a) Panel Mounted Digital Indicators For Field Instruments

Digital panel indicators shall be microprocessor based and modular in design. It shall accept 4-20 mA DC isolated input. The digital panel indicator shall provide an output of 4-20 mA DC proportional to input signal for retransmission. It shall have RS 485 communication port for connectivity to PLC.

Technical Particulars

Type	:	Microprocessor based.
Mounting	:	Front facia of Instrument Control Panel(ICP)
Display	:	Back-lit LCD or LED
Digit height	:	12.5 mm or higher
No. of digits	:	4
Input	:	4-20 mA DC (isolated)
Zero & Span adjustment	:	Required
Engineering units for display	:	As per site requirement
Weather protection class	:	IP-52 of lS 13947
Retransmission output	:	4-20 mA proportional to Process variables.
Relay outputs	:	Required 2NO+2NC for high level alarm and 2NO+2NC for low level alarm
Communication port	:	RS-485 (With Modbus protocol)

(b) Kilowatt-hour meters.

Kilowatt-hour meters shall comply fully with IS 722 or BS 5685 Class 2 and shall have industrial grade accuracy (±2.5%). Three element units shall be used for 3 phase 4-wire systems. Two element units shall be used for 3 phase, 3-wire systems.

Quantity : 1 No. for each pump and incomers of 3.3 kV (or more) Switchboard (250 KW & above motors) As per site conditions.

Purpose : Power and Energy Monitoring

It shall monitor voltage, current, kW, kVAr, kVA, power factor and frequency.

Technical Particulars

Data logging

Data storage and it shall be retrieved via RS 485 port

Soft Integration

The meter shall be integrated with SCADA system to provide remote display of all measured parameters and meter configurations. The metering shall be via. RS 485 port.

Measurement

- True RMS measurement
- Instantaneous phase voltages, line voltages, phase currents and line currents
- Frequency
- Active, reactive, apparent powers and power factor per phase and line
- Energy-Import and Export
- Maximum demand kVA, kW, kVAr

Communications

- RS 485
- Baud rates minimum 9600

Accuracy Class

- 0.5 S

Accuracy Standards

- IS-14697:1999

Front Panel Display

- LCD with back lighting
- Display for all basic power and energy parameters
- Password protection for setup parameters

Ratings

Voltage Inputs

- 50 to 347 VAC

- Accuracy VL-N: 0.25% reading
- Accuracy Hz : +/- 0.1 Hz
- Support 3 phase 3 wire, 3 phase 4 wire connections
- Standard screw in terminals

Current Inputs

- 5 Amp. nominal
- Accuracy current: 0.25% reading
- 20% over range full accuracy

Power Supply

- 110 V to 240 VAC & VDC

Environmental Conditions

- As per process Requirement- Ambient Temperature.
- Humidity: upto 95% non condensing

Dimension: Appr. 96x96x96 mm

(c) Microprocessor based Alarm Annunciator

(1) Microprocessor based alarm annunciator shall be provided for generating audio-visual alarms for each abnormal condition. Alarms shall be initiated by the opening and closing of volt-free contacts which shall remain unchanged throughout the periods in which the alarm conditions exist. Alarm circuits shall be capable of conversion from open-healthy to open-alarm or vice versa by a simple configuration after installation requiring no additional parts or special equipment. Each alarm shall initiate the operation of both visual and audible devices. The sound intensity (adjustable) of each audible device shall be suitable for the maximum sound level of its environment

(2) Each alarm shall initiate a visible and audible indication of the specified condition. Unless otherwise specified, alarm indicators shall be grouped together in annunciator units each having at least 20% spare windows. Each alarm window shall consist of minimum 2 nos. of bulbs having cluster of LEDs and shall have screens engraved with legends approved by the Engineer's Representative.

(3) When any alarm condition occurs, an audible device common to an alarm annunciator system shall sound and the appropriate indicator shall flash on and off. The flashing rate shall be selectable. Facility for selection of type of sequence shall be provided.

(4) The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a future alarm condition occurs.

(5) An integral 'test' pushbutton shall be provided to illuminate each lamp and to operate the audible device but shall not cause a spurious alarm condition.

(6) Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds adjustable do not initiate any action.

(7) Isolation facility shall be provided for the hooters.

(8) Alarm annunciator/indicator legends or labels shall be arranged with three lines of text as follows:

(i)	top line	:	Location
(ii)	middle line	:	Parameter
(iii)	bottom line	:	Status
e.g.		:	RESERVOIR LEVEL LOW

(9) Alarm annunciator shall have RS-485 communication port (Modbus protocol) for interfacing with the PLC system.

(10) A LED shall be provided to indicate the 'ON' status of the alarm annunciator.

Technical Particulars

Alarm annunciator shall be provided on instrument control panel for annunciation of alarms in control room. The technical particulars of alarm annunciator are as follows:

i.	Type	:	Microprocessor based, split type with alarm windows mounted on the front door and electronic modules inside the panel.
ii.	Mounting	:	Flush with panel
iii.	Construction	:	Modular
iv	Inputs	:	Potential free, NO/NC contacts
v	Size of windows	:	60 mm X 26 mm
vi	Operating sequences	:	First up (user selectable dip switch)
vii	Bulbs per channel	:	2 (Cluster LEDs)
viii	Push Buttons	:	For Test, Mute, Acknowledge & Reset
ix	Hooter	:	Required, electronic type
x	Power supply	:	24 V DC/240 V AC
xi	Power supply status Indication	:	Required
xii	Weather protection	:	IP-52 of IS 13947
xiii	No. of Windows	:	8 / 12 / 24, As required with 20 % Spare
xiv	Quantity	:	As per process requirement

7.9.3 Indicator Lights

Indicator lights shall be not less than 20 mm diameter and shall be panel mounted types with metal bodies adequately fastened so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lampholder or panel wiring. Lampholders shall be keyed into panels to prevent rotation. Lens colours shall comply with BS EN 60037 as follows:

-	power on	white*
-	running -	green
-	tripped/alarm	red
-	status (open, closed, etc)	blue
-	ready to start	blue
-	warning (no imminent danger)	amber

Note: *white may be used where doubt exists as to which other colour to use.
The lights shall be under-run to give long life either by use of a resistor to limit voltage to 90% normal value or by using higher voltage lamps.
The indicating lamps on control panel shall be cluster of LED's.

7.9.4 Pushbuttons

Colours of pushbuttons shall generally comply with IS 6875, BSEN 60947, 60037 or IEC 60073 and in particular shall be as follows:

-	stop, emergency stop	red
-	start	green
-	jogging/inching	black
-	reset (when not also acting as a stop)	blue
-	lamp test	blue
-	override/alarm accept	yellow

7.9.5 Specification For Junction Boxes:

(A) Junction box (instrument)

1	Construction	:	3mm sheet steel hot
2	Protection	:	IP 65
3	Paint and shade	:	One coat of red oxide primer Powder coated light grey as per Dhade 631 of is:5
4	Terminal strip		Elmex type capable of

			Terminating 0.5 sqmm to 1.5 sqmm Cable din rail mounted
5	No of terminal strips		30/40/70 Rating:600v 10 a ac
6	Conduit & cable entry		Lower side
7	Gland plant thickness		3mm
8	Door of JB		Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lids When completely unscrewed (captive screws)
9	Dimension		Vendor to provide most Economic dimension of JB based
			On the no of Terminal bases and cable Entry
10	Mounting		Frame mounted
11	Earthing		Two no of earthing bolts for JB Earthing separate instrument Earth bus on insulating clits to be provided
12	Name plates		To be provided material: white Engraved letters on black Anodized aluminum sheet Fixing: stainless steel screws Lettering:- black with white Engraved

(B) Junction box (power & control)

1	Construction	:	3mm sheet steel hot
2	Protection	:	IP 65
3	Paint and shade	:	Power coated light grey as per Shade 631 of is:5
4	Terminal strip		Elmex type capable of Terminating 0.5 sqmm to 1.5 sqmm Cable din rail mounted
5	No of terminal strips		30/40/70
6	Conduit & cable entry		Lower side

7	Gland plate thickness	3mm
8	Door of JB	Hinged with proper locking Arrangement to avoid entry of Dust & moisture the design of Fixing screws of the lids of the Junction box shall be such that They do not come out of the lid When completely unscrewed (captive screws)
9	Dimension	Vendor to provide most Economic dimension of JB based On the no of Terminal bases and cable Entry clearly specifying GA Drawing
10	Mounting	Frame mounted
11	Earthing	Two no of earthling bolts for JB Earthing
12	Name plates	To be provided material: white Engraved letters on black Anodized aluminum sheet Fixing: stainless steel screws Lettering:- black with white Engraved.

7.10 Cabling

7.10.1 Instrumentation cabling

Cables from conventional measuring transmitters and analogue process controllers, such as digital or 4mA to 20mA dc output from a constant-current source, (hereinafter referred to as high-level signals) shall be polyethylene or PVC insulated with stranded conductors and laid up as twisted pairs with one twist per 30mm approx. Each cable shall have an overall screen of braided copper or mylar backed aluminium foil giving a minimum coverage of 85%, a steel wire armouring insulated from the screen and from any ducting and an overall PVC sheath. For runs exceeding 30 metres or for all inputs to a data logger, computer or microprocessor, multi-core cables shall have an individual screen of braided copper or mylar-backed aluminium foil for each signal pair. The minimum conductor size shall be 24/0.2mm but shall be of greater cross-sectional area if required for the satisfactory operation of associated plant. Cables for intrinsically safe systems shall comply with BS 5308 and the relevant certificate.

Cables from strain gauges, analysers and the like, such as 0 to 100mV (hereinafter referred to as low-level signals — see also below) shall be as specified above and shall have an individual screen for each signal pair.

Cables from indicating devices to alarm or tripping circuits shall be as specified above for high-level signals but shall use cables, cable trays, ducts and conduit separate from those for other high-level circuits.

Cables for high-level signals, low-level signals, resistance thermometers and thermocouples shall be segregated from each other and each shall be separated from cables for power, communications and other electrical services. Other cables run in the vicinity of instrumentation cables shall be twisted at the rate of one twist per 50mm approximately and shall be separated from instrumentation cables by a distance of not less than 300mm.

Initiating devices for plant protection and personnel safety shall be connected by individual cables direct to the tripping or safety device and shall not be routed via any intermediate junction, marshalling box, cabinet, relay or similar. The outer sheaths of such cables shall be coloured orange.

Technical particulars:

(i) Contractor shall include in his scope the supply, laying of cables and associated civil/mechanical work.

(ii) Cables shall be capable of satisfactorily withstanding without damage, transportation to site, installation at site, and operation under normal and short circuit conditions of the various systems to which the respective cables are connected when operating under the climatic conditions prevailing at the site as indicated in this specification.

(iii) Cable joints in instrument signals and power supply cables shall not be permitted.

(iv) Cables shall be capable of satisfactory performance when laid on trays, in trenches, conduits, ducts and when directly buried in the ground.

(v) Cables shall be capable of operating satisfactorily under the specified power supply system voltage and frequency variation.

a) Cables for analog signals

The cables shall comply with the following requirements:

Cables of 1100V grade, multi-pair/multi-triad cable, annealed, tinned, high conductivity, 1.5 sq. mm. stranded copper conductor, extruded PVC insulated two/three cores twisted into pair/triad, laid up collectively, individual pair/triad shielded and overall shielded with aluminium mylar tape, ATC drain wire run continuously in contact with aluminium side of the tape, inner sheathed with extruded PVC, armoured with galvanised steel wire and overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be used for analog signals.

b) Cables for digital signals

The cables shall comply with the following requirements:

Cables of 1100V grade, multi core cables, annealed, tinned, high conductivity, 1.5 sq. mm. stranded copper conductor, extruded PVC, overall shielded with aluminium mylar tape, inner sheathed with extruded PVC, armoured with galvanised steel wire, overall sheathed with extruded PVC conforming to IS 1554,IEC 189 & BS 5308 shall be used for digital signals.

c) Cables for Instrument/Equipment power supply

The cables shall comply with the following requirements:

Cables of 1100V grade, multicore cable, annealed, tinned, high conductivity, 2.5 sq. mm. stranded copper conductor, extruded PVC, inner sheathed with extruded PVC, armoured with galvanised steel wire, overall sheathed with extruded PVC conforming to IS 1554, IEC 189 & BS 5308 shall be provided for Instrument/Equipment power supply.

7.10.2 Telemetry cabling

Telemetry cabling between a master station and an outstation, unless otherwise specified, shall consist of a minimum of 6 signal pairs, of which two pairs shall be allocated to the telemetry system, one pair shall be allocated to a speech circuit and three pairs shall be spare. Each conductor shall be multi-stranded with an equivalent diameter of not less than 0.9mm. Conductors shall be laid up in starquad formation. The dc resistance of any pair of conductors shall not exceed 88 ohms per loop mile at 10°C and the difference between the resistances of the conductors of any pair shall not exceed 0.5% of the loop resistance of that pair.

Telemetry cables shall be designed for burying in water-logged ground.

Conductors shall be plain annealed copper with aluminium/polythene laminate sheath moisture barrier, copper or brass tape pest barrier, single galvanised steel wire armour and overall polythene sheath. The cable shall have a solid filling of petroleum jelly.

The characteristic impedance of each signal circuit shall have a nominal value of 600 ohms at 800Hz and the circuits shall be suitable for signal input levels of between −30dbm to +4dbm (0dbm = 1mW into a load of 600 ohms). The overall attenuation between the terminations of any circuit at the mean frequency of the band width specified elsewhere shall not exceed 20dbm and the attenuation at any two frequencies within this band width shall not differ by more than 6dbm. The transmission time for any two frequencies within the band width specified elsewhere shall not differ by more than 1 / (4 % B) seconds, where B is the transmission speed in bauds, as specified elsewhere.

The signal-to-noise ratio within the bandwidth specified elsewhere shall be better than 12db. The frequency of any received signal shall not differ from the frequency of the corresponding transmitted frequency by more than 1% of the transmission speed in bauds specified elsewhere.

Loading coils as necessary to meet the performance requirements detailed herein shall be supplied and installed at equally-spaced points.

(a) Fiber optic cable

To facilitate the proper and efficient co-ordination of the Works the Contractor shall sublet all Cabling Works to one Sub-Contractor who has proven and successful experience in fiber optic cable installations on projects similar to the one now proposed.

If cable sizes are not indicated on Drawings or in schedules, determine the correct size based on total end to end signal attenuation not to exceed 40 dB, including all splices and termination losses, and after taking into consideration.

a) Type of fiber
b) Ambient conditions
c) Method of installation
d) The disposition of each cable relative to others

All cables and wires shall be suitable for installation and continuous services in the ambient conditions described elsewhere in this document.

Shop Drawings and Product Data shall be submitted for the approval of the Engineers as follows;

- Submit full technical details of each type of cable proposed.

- Submit copy of test certificates from the manufacturer or an independent testing authority

confirming that cables comply with the specification.

- Submit exact route of the cable run and relevant Sections in the shop drawings.

Each drum length of cable shall be allotted a distinct and separate reference number. This number shall appear on the test certificate covering the respective length of cable and shall also be clearly marked on the cable drum.

The Contractor shall advise the Engineer upon delivery to site of each drum length, quoting the reference number, the test certificates shall be handed to the Engineer for examination and approval. All cables shall be delivered to site with the manufacturer seals, labels or other proof of origin intact. These labels and seals shall not be removed until the cable is required for use and shall be retained for inspection by the Engineer.

The Contractor shall be responsible for the off-loading and handling of the cables on site, and shall ensure that cables are delivered to site on drums and properly protected against mechanical damages. Where lengths are cut from cables, the open ends shall be sealed.

The contractor shall be aware of the need to supply and install all cables for this Contract which are most suitable for the special environmental conditions prevailing in this project.

The cable shall comprise 8 fibers, loose tube, two fibers per tube with central 1.5 mm nominal steel central strength member, moister barrier, steel tape armored in continuos lengths up to a maximum of 6.0 km or as dictated by cable joint chamber locations and route survey.

Single Mode	
Type of fiber	Single mode, doped silica
Core Diameter	9.0 ± 0.5 micro m
Cladding Dia	125 ± 2.0 micro m
Coating (outer) Diameter	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.11 micro m
Attenuation	<0.4 dB/km @ 1300 nm <0.2 dB/km @ 1500 nm
Bandwidth	1000 MHz @ 1300 nm
Chromatic Dispersion	3.5 ps/nm x km @ 1300 nm 20 ps/nm x km @ 1500 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)

Multi mode	
Type of fiber	Multi mode, doped silica
Core Diameter	62.5 ± 3.0 micro m
Cladding Diameter	125 ± 2.0 micro m
Coating (outer) Dia	250 ± 15 micro m Material UV curable acrylate
Numerical aperture	0.275 + 0.15 micro m
Attenuation	<3.2 dB/km @ 1300 nm <0.9 dB/km @ 1500 nm
Bandwidth	500 Mhz x km @ 1300 nm
Operating temperature range	-30 to +80 deg. C
Crush resistance	>200N/cm
Weight	500 kg/km (maximum)
Tensile strength	2000 N (minimum)

7.10.3 Cable termination boxes

Cable termination boxes shall have double-ended screw terminals with removable links to facilitate core isolation during testing. Each box shall contain sufficient terminals for every conductor plus 20% spare terminals. Cable termination boxes shall have cable sealing chambers and insulated glands with earthing terminals so that the armouring may be earthed or isolated from earth, as circumstances dictate.

Termination boxes for use within buildings shall be of sheet steel with hinged or removable front covers. All other termination boxes shall be cast steel or heavy gauge sheet steel construction giving protection to IP55. All termination boxes shall be hot-dip galvanised or approved equivalent finish. Each terminal box shall have a removable, un-drilled gland plate and the Contractor shall supply and fit the requisite number of cable glands.

At each cable termination box, each cable core (including spares) shall be identified by a numbered slip-over type collet. The numbering for a particular cable core shall be the same throughout its length.

Cable joints shall be at points approved by the Engineer.

Each cable joint shall be of the straight-through type. The conductors shall be ferrule-jointed with the insulation maintained by heat-shrink sleeving. Joint closure shall be made with epoxy resin and the completed joint shall be impervious to water if submerged or in waterlogged ground. If cast iron joint boxes be used, they shall be provided with cable glands and, after installation and testing, shall be covered with Densomastic HD compound or equal; so that all sharp corners, bolts and projections are moulded to a smooth surface. Two lappings of Densopol grade ZN 50mm tape, or equal, shall then be applied overall. Jointing shall be carried out on each conductor, including any provided in excess of the minimum quantity specified. All materials and things of every kind required for the cabling jointing shall be provided by the Contractor.

7.10.4 Cable labeling

At each end of each cable, in a uniform and visible position, a label shall be fixed on the cable to indicate the site cable number and route, and the number and size of conductors. Labels shall be made of brass, aluminium, lead or copper strip, engraved and retained by suitable non-rusting or non-corrodible binding wire passing through two fixing holes, one at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

Three-phase power cable cores shall be identified A, B, C or colour-coded red, yellow, blue so that the correct three-phase sequence is preserved throughout the system. Single-phase power cable cores shall be colour-coded red and black.

Control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same number at both ends. Core identification shall occur at every point of termination using an approved system of colour-coded ferrule markers. The size of these ferrule markers shall be such as to match the overall diameter of conductor plus insulation. Numbering shall read from the termination upwards on all cores.

Each cable and core shall bear the same number at both ends of the cable and core respectively.

(a) Power terminations — colour, number or letter.

(b) Control terminations — letter or number or both.

7.10.5 Cable terminations

All PVCSWAPVC, PVCPVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall comply with BS 6121. They shall seal the inner and outer cable sheaths against ingress of dirt and moisture and provide adequate mechanical support. Each cable gland shall be protected by corrosion-resistant molded PVC hoods, covering the entire assembly from the overall sheath to the gland neck.

Glands for armoured cables shall provide a positive armour clamp to the enclosure so that no tension is applied to the termination. The clamp shall also provide a high level of earth continuity and be of adequate size to withstand the full fault current of the system for one second.

All glands shall be provided with an earthing tag. For cables of $4mm^2$ or less, a serrated washer may be used instead for earth continuity.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer‘s instructions.

Through joints shall be permitted only on long cable runs outside buildings. Where such joints are necessary; the cables shall be jointed with epoxy or acrylic resin Cold-setting compound which has been pre-measured and pre-packed ready for use.

The boxes shall be of a split moulded plastic type with filling vents for compound.

Bonding straps shall be fitted with armour clamps across the joint and inspected by the Engineer prior to filling the box with compound. Wrapped pressure type joints shall not be accepted.

Conductor cores shall be jointed number to number or color to color.

7.10.6 Cable installation-general

Cables which are to be run on walls, ceilings or other building structures shall, unless otherwise agreed by the Engineer, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members. Cables shall not be installed in areas of direct sunlight.

Where this is unavoidable, approved sun shields shall be supplied and installed.

Where the building structure incorporates purpose-built covered duct or trench systems for main cables, instrumentation cables shall be segregated and installed on tray work or otherwise secured to the sides of the duct or trench.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the walls unless otherwise agreed by the Engineer.

Cables shall be spaced to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles and cleats shall prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings, such as rawlplugs.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand Site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used. The arrangement and fixing of each cable shall permit the removal and replacement of any cable without disturbance to any other cable or the fixings thereof.

When cables are terminated in any particular item of equipment, special care shall be taken to ensure that the cables finally approach the equipment from a common direction and are individually terminated in an orderly and symmetrical fashion.

Submissions which the Contractor shall submit the following in relation to cable installations in addition to submissions detailed elsewhere in the Specification.

7.10.7 Drawings and schedules:

- Block diagrams to show control cabling systems with each cable and terminal equipment being identified as in the cable schedules.
- Cable route and layout drawings. For those items which are underground, these drawings shall include the following:
- Route plans and sectional views for all cable runs, cable trays, cable ducts and cable trenches;
- The position of all marker posts, joints, draw pits and the like.
- Cable schedules shall detail the cable number, type, voltage, size, route length and number of cores or pairs. Control-cable schedules shall detail the connected and spare core numbers, diagram number for connected equipment, core ferrule and terminal reference number.

7.10.8 Data and calculations:

- Manufacturers‘ catalogues and data sheets for all cables and fittings. Cable sizing Calculations.

7.10.9 Test certificates:

- Test certificates for all witnessed and routine tests carried out at the manufacturer‘s works and at Site (calibration).

7.10.10 Cable trays and ladders

Cable tray and cable-support ladders shall be of heavy-gauge galvanised steel and with an overall PVC coating when required to the approval of the Engineer.

Cable tray and ladder systems shall be installed using factory-made supports, joints and junction/bend pieces. Wherever tray and ladder sections are cut and shaped on Site, cut edges shall be dressed and painted with at least two coats of cold galvanising compound or lead-based anti-corrosive paint.

Ladder systems shall be secured to walls and ceilings by pre-formed galvanized interlocking channel.

7.10.11 Flexible conduits

Flexible conduit shall be of the waterproof galvanised type of PVC wire-wound type with cadmium-plated mild steel couplings. Lengths of flexible conduit shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a trough-type box. The flexible conduit shall extend from this box to the equipment; the earth continuity cable shall be secured to the box and to the piece of equipment. The use of lid facing screws and the like will not be permitted. Adaptors shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

7.10.12 PVC conduit

Where galvanised conduit would be liable to corrosion, PVC conduit shall be installed.

PVC conduit shall be of the oval or round high impact non-flame-propagating type as specified and

self-extinguishing, to BS EN 61386-21. Surface and concealed installations shall be generally as

described for steel conduit.

PVC conduit fittings shall comply with BS 4607. They shall all be white unless specified otherwise.

Jointing shall be carried out using PVC solvent and socketed accessories.

Expansion couplers shall be fitted in straight surface runs every 12m. The free end shall be sealed with non-setting mastic to form a waterproof seal.

Purpose-made bends may be used providing that the cable bending radius is maintained. Cracked or crinkled conduit will be rejected.

The conduit shall be suitable for use in ambient temperatures of between −5°C and +60°C and shall not be installed in areas that receive direct sunlight. A separate protective conductor (earth-continuity conductor) shall be installed.

Adaptable boxes and accessories shall be made from heat-resistant insulating material. The minimum wall thickness of boxes having a nominal internal depth of 16mm or less shall be 1.5mm. For deeper boxes, the minimum wall thickness shall be 2mm. All boxes which are intended to support luminaires or other heat sources shall have either external fixing lugs riveted to the metal inserts or utilise steel insert clips.

7.11 Cable installation methods

7.11.1 General

All cabling installation methods shall be subject to the approval of the Engineer.

7.11.2 Installation directly into the ground

Where cables are buried in the earth, the bottom of the excavated trenches shall be freed of sharp stones and other projections and covered with sand to a depth of 50mm.

Cables shall be unrolled from drums without loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath by drawing over sharp projections.

Cables shall be snaked into the trenches to avoid tension in the cables during backfilling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of 100mm of compacted sand and shall have a layer of protective interlocking concrete cable tiles. The tiles shall be overlaid with marker tape.

When cables of different voltages are laid together at the same depth, vertical cable tiles shall be used to segregate the cables.
ICA and communication cables shall be laid not closer than 1000mm to high voltage cables.

A sufficient number of rollers shall be provided so that the cable does not touch the ground or twist during pulling.

7.11.3 Installation in underground ducts

Underground ducts shall be constructed of impact-resistant uPVC and laid at a minimum depth of 500mm (to the duct centre), surrounded by at least 75mm of sieved sand. At road crossings, uPVC ducts of minimum diameter 100mm shall be laid at a minimum depth of 1000mm (to the duct centre). The ducts shall be encased by 150mm concrete on all sides.

When installing cables in ducts, the following measures shall be observed:

- Cables shall be pulled in a straight line;
- Rollers shall be positioned at the edges of drawpits both at the drawing-in and drawing-out points over which the cables shall be drawn;
- uPVC pipes and cable sheaths shall be coated with an approved lubricant;
- Sufficient draw-in points shall be provided and adequate room allowed for installation of cables;
- The pulling rope shall be guided by rollers. Only one power cable shall be drawn into each duct.

Whenever a duct is laid in the ground, a draw-wire shall be pulled through with at least 1000mm excess at each end and the draw-wire left in position if the duct is not to be used immediately.

7.11.4 Sealing cable entries into buildings

Whenever cables pass through walls below ground level, the point of entry shall be sealed against the ingress of water. This shall be achieved with silicone foam or similar.

All cable entries into a building shall be in ducts and where the cables pass in or out of ducts, together with any spare ducts, the ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes.

7.11.5 Marking of underground cables

The location of all underground cables shall be identified by:

- Brass plates fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall;
- Marker posts in road verges and the like at intervals of not more than 100m and at all junctions and changes of direction along the route;
- Marker posts at 10m intervals within an enclosed site and at all junctions and changes of direction along the route.

  Marker posts shall be of concrete, not less than 200mm high above ground with an inscribed brass or enamel metal plate. The inscription shall indicate the presence of a cable below, the depth, classification and voltage rating.

A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer.

7.11.6 Installation in cable trunking

Cable trunking shall be manufactured from mild steel of not less than 1.25mm and shall be hot-dip galvanised. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity. Trunking shall have minimum dimensions of 50mm % 50mm.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining quick-fix type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose-made by the

manufacturer and of a matching design to the main trunking.

Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.

Trunking shall be supported at intervals not greater than 2m horizontally or 2.5m vertically.

Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking, the bared ends shall immediately be given a coat of zinc-rich cold galvanising paint.

Cable and trunking runs shall be determined by the Contractor and agreed by the Engineer before any work is started. The run shall be at least 150mm clear of plumbing and mechanical services.

Trunking systems erected outside a building shall be weatherproof.

7.11.7 Installation in troughs and trenches

Where the building structure incorporates purpose-built covered trench systems, power distribution cables may be laid on the floor of the trench. Control and instrumentation cables shall be segregated and installed on supporting steelwork or cable trays secured to the walls of the trench.
Where the building structure incorporates general service trenches containing pipework, chemical lines and other services, all cabling shall be segregated from other services and run on the trench walls. Crossovers shall be kept to a minimum and cabling shall be taken above wet service pipework.

Cable trays shall be of perforated steel with formed flanges and of minimum thickness not less than 1mm for trays up to 100mm width, not less than 1.25mm for trays from 100mm to 150mm width and not less than 1.5mm thickness for trays from 150mm to 300mm width.

Cable-tray supports shall be of sufficient strength to maintain rigid support to the fully-laden cable tray along its entire length. All brackets and tray work shall be suitable for withstanding a temporary weight of 125kg.

Wherever possible, cable trays shall be installed in full lengths without cutting.

Should it be necessary to cut or drill a length of tray, the bared ends shall be dressed and immediately be given a coat of zinc-rich cold galvanising paint. Similarly for PVC-coated trays, the bared end shall be immediately sprayed using a PVC aerosol.

All cables shall be firmly secured to the tray using purpose-made saddles, as approved by the Engineer, together with proprietary cable cleats.

7.11.8 Installation in buildings

Cables required to be run on walls, ceilings, or other structures shall be carried on substantial cleats, either in groups or simply at spacings determined by rating requirements, supported on tray or ladder racks or enclosed in conduit or trunking.

All cables shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips and the like shall be by means of non-corrodible screws inserted into approved wall fixings.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

Hangers shall be spaced according to recommendations in the IEE Wiring Regulations. Allowance shall be made for expansion and contraction of the cables.
Cables shall be located between 50mm pegs spaced at 40mm centres across a rung so that a 40mm or 80mm space is maintained between cable centres. Cleats shall be used where the ladder racking is vertical.

Cables shall be run at least 150mm clear of plumbing and below heating and hot water pipework.

7.11.9 Cable installation in conduits

Conduits shall be either galvanised heavy-gauge steel screwed type or light-gauge steel non-screwed type, steel or PVC. Accessories shall either be malleable cast iron or pressed steel.

A space factor of 40% shall not be exceeded and, in any case, conduit shall have a minimum diameter of 20mm. The tubing is to be perfectly smooth inside and out and free from imperfections. Both ends of every length of tubing shall be reamed and all sharp edges removed before erection.

Where conduits converge, adaptor boxes shall be used. Conduits shall be connected by means of male brass bushes and couplings. Where conduits are greater than 25mm diameter, straight-through joint boxes shall be of

the trough type. Where conduit or fittings are attached to equipment casings, the material of the casing shall be tapped for a depth of not less than 10mm or male bushes and flanged couplings may be used.
Hexagonal lock nuts shall be used at running joints. They shall seat firmly and evenly on to mating faces. All function boxes, draw-in boxes, and inspection fittings shall be placed so that the cables can be inspected, withdrawn and re-wired during the life of the installation.

Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits during erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators or appliance fittings.
Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt and covers shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings. Where they cannot be installed in any other manner, a galvanised flexible conduit shall be used across the expansion joint. A total of 150mm movement shall be allowed.

7.12 Process Instrumentation

7.12.1 General

Instrumentation system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

All instrumentation equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalised. The outdoor equipments shall be designed to withstand tropical rain. Wherever necessary space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.

Electronic instruments shall utilise solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.

No custom made hybrid type integrated circuits shall be used.

Unless otherwise stated, overall accuracy of all measurement systems shall be ±1% of measured value, and repeatability shall be ±0.5%.

Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.

On resumption of the supply following a power failure the instruments and associated equipment shall start working automatically.

The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.

Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof to IP-65.

The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail but in any case not less stringent than those conditions detailed in the Project Requirements. Instruments shall be resistant to corrosion in the atmosphere in which they are expected to operate.

Lockable enclosures shall be provided for all the field mounted instruments.

All field instruments, and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Employer for approval before any labels are manufactured.

All coated parts of sensors shall be made out of non corrosive material capable of working with chlorine content of 5 ppm.

For all instruments installed in the field, surge protection devices (SPD s) shall be provided at both ends of the connecting cable for protection against static discharges / lightning and electromagnetic interference.

Individual pair screened, overall screened, armoured cables shall be used for analogue signals and armoured, overall screened cable shall be used for digital signal cables.

7.12.2 Flow Measuring Systems

Flow measuring system shall consist of flow sensor / transducers, flow computer and flow transmitter.

Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation in underground/above ground pipelines.

To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow sensor shall be provided in accordance with the requirements of the flowmeter manufacturer.

The flow transmitter shall be suitable for field or panel mounting and shall accept an input from the flow sensor. It shall process the input signal and provide 4-20 mA dc output proportional to flow rate. The flow range shall be adjustable.
A zero span adjustment facility shall be provided for flow transmitter and indicator.

Flow measurement shall not be affected by physical properties of sewage viz., temperature, pressure, viscosity, density etc., within given limits. Contractor shall provide compensating electronic circuits if required. The overall accuracy of flow measuring systems shall be at least ±1.0 % of the measured value unless otherwise stated.

(a) Electromagnetic Flow Meter (Full Bore)

(b) General

The Electromagnetic Flow Meters shall be installed in RCC chambers / open pits or buried for indication of flow rate and total consumption of water in a transmission or distribution pipe work of water supply system.

The Electromagnetic Flow Meters shall withstand maximum working temperature and working pressure shall be as per process requirement.

Electromagnetic Flow Meter

Full bore electromagnetic flow meters shall be designed, manufactured and calibrated to ISO standard. The flow meter shall be capable of measuring bi-directional flow.

General Specification

Electromagnetic Flow Meter shall be a velocity sensing electromagnetic type, microprocessor based signal converter, Flow Integrator and Totalizer sealed housing, flanged tube meter as per working pressure requirement. The meter shall be manufactured to highest standard available for mag-meters. The accuracy shall be inclusive of linearity, hysteresis, and repeatability, temperature and pressure effects. The meter assembly shall operate within a range of 0.3 m/sec to 5 m/sec and pressure rating shall be as per process requirement to be constructed as follows

Meter tube shall have a constant nominal inside diameter offering no obstruction to the flow.

Signal Converter shall be pulsed DC coil excitation type with auto zeroing. The signal converter shall be remotely mounted away from the meter.

The converter shall indicate direction of flow and provide a flow rate indication and a total of flow volume for both forward and reverse directions.

The converter shall provide an isolated 4-20 mA output into minimum 600 ohm load and a frequency output of a maximum of 0-10 KHZ and a scaled pulse output.

The microprocessor based signal converter shall have a self-diagnostic test mode and backlit display that continuously displays 'Rate of Flow‘ and 'Total Volume‘.

The converter shall be compatible with Miscrosoft Windows and other software programs with built in terminal communication capabilities of RS 485, HART or other protocols for interface.

The converter shall be remotely mounted maximum upto 200 m from the sensor, and shall be supplied with all calibration complete for desired requirements.

The converter cum transmitter shall be fully programmable from the front facia. The

programming shall be user friendly, self-prompting menu driven.

The length of the sensor shall be strictly as per ISO upto DN 600 mm and for other sizes it shall be as per the manufacturer‘s standard. Only, one manufacturer shall make all meter size and styles required for this contract.

(b) Open Channel Flow meter

Open channel flow measuring systems shall consist of level transducer, flow computer and flow transmitter. The level of the fluid in the flume shall be measured by the ultrasonic level transducer. The level measured shall be used along with the physical characteristics of the flume to compute the flow rate.

The level transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected as per IP65. It shall have ambient temperature compensation and adjustable datum setting facilities.

The design and application of ultrasonic level meters shall take into account the channel construction, the material size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For application where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

The structure required for supporting the level sensor, platform, railings etc shall be in the Contractor‘s scope.

7.12.3 Level Measuring System

(i) Ultrasonic Level Meters

Ultrasonic level measuring devices applied for level measurement shall comprise a transducer, control unit and remote indicator.

The transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected to IP 65. It shall have ambient temperature compensation, adjustable datum setting facilities.

The accuracy of the sensor shall be ±0.25% or better.

It shall be programmable with an integral programming keyboard and provide a digital display of the measured variable. It shall be provided with diagnosis facilities and shall provide an isolated 4 to 20 mA dc output signal proportional to the range of measurement.

The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

If turbulence exists, shielding, stilling tubes or other measures shall be provided to avoid effects on the measurement.

(ii) Conductivity Level Switches

The electrodes used for conductivity level switches shall be stainless steel. Single electrode systems (one electrode per holder) shall be used (except where their use is impractical) with insulated electrodes such that only the tip of each electrode is exposed to the liquid at the operating level.

Relay or control units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall be fitted with conductivity discs.

Where relay or control units are not mounted in control panels, they shall be provided with surface mounting enclosures with a degree of protection to IP 52 for indoor locations or IP 65 for outdoor locations.

7.12.4 Pressure gauges and transmitters

Pressure gauges shall comply with BS EN 837-1 or equivalent and have concentric scales. For specially arduous duty where the gauge is subject to pressure pulsations and/or vibration, it shall be provided with a glycerine-filled dial and line snubbers shall be used. Bourdon-tube type differential-pressure gauges shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage to or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material.

The minimum diameter for round pressure gauges shall be 100mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

Unless specified elsewhere the accuracy for pressure gauges shall be 1% of range, for diaphragm gauges 1% of range and for differential gauges 1.5% of range or better.

Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation shall be marked on the dial.

The zero and span of a pressure transmitter shall not change by more than 0.1% of the span per Celsius degree change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed 0.1% of the span.

Pressure transmitters shall have an accuracy typically better than 0.1% of span, depending on the application and shall be protected to BS EN 60529: IP 65 standard or higher standard. For transmitters installed in meter chambers liable to flooding or underwater applications, they shall be to BS EN 60529: IP 68 standard and shall operate up to maximum submergence of 20 metres of water.

Pressure transmitters shall provide a digital or 4mA to 20mA dc output proportional to the pressure range.
Pressure gauges and transmitters shall have primary isolating valves, 2 or 3 way valve manifold and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.

7.12.5 Strain-gauge pressure transducers and transmitters

Strain-gauge pressure transducers shall use thin film sensors without bonding.

Each instrument housing shall be of all-welded Grade X 4 CrNiMo 17 12 2 stainless steel or equivalent and hermetically sealed. Non-interacting, zero and span adjustments shall be provided on each transducer. The measuring diaphragm shall be isolated from the process fluid by a non-corrodible barrier diaphragm. The mean time between failure for any model of strain-gauge transducer shall be not less than 15 years, and the performance of the measurement system shall be as given below, or higher performance:

- Accuracy: ±0.1% of calibrated span, including linearity hysteresis and repeatability;
- Repeatability: ±0.05% at maximum span;
- Stability: ±0.1% of upper range limit over 6−month period;
- Over-pressure: sustain a 400% over-pressure without damage;
- RFI / EMI effect: less than 1% of span with 500MHz at 5W direct contact;
- Power-supply variation effect: 0.01% per volt variation.
- Load variation effect: ±0.0002% per ohm of loop-resistance variation.
- Temperature: −29°C to +82°C range; total thermal error of ±0.75% of span over 0°C to 50°C;
- Protection: IP 65.

Strain-gauge transducers which do not have terminals for their cable connection, shall have integral sealed-cable assemblies, installed in conduit and terminated at weatherproof junction boxes, protected to IP 65 each mounted near to its associated process transmitter. A digital or 4mA to 20mA dc output signal proportional to the transducer range shall be provided.

Strain-gauge pressure transmitters shall be generally as the transducer except that it shall incorporate a waterproof pressure transmitter producing a digital or 4mA to 20mA output signal.

Provision for transducer venting shall be provided.

7.12.6 Temperature Monitoring System

Microprocessor Based Multi-Channel Temperature Scanner and Indicators

Panel mounted microprocessor based multi-channel temperature scanner shall be provided to continuously monitor temperature at different positions in each pump-set. The scanner shall have provision of accepting RTD/ thermocouple inputs. Facility shall be provided for grouping of channels for generating alarm/trip signals. Each scanner shall generate two nos. of potential free contacts for each group. The scanner shall have facility for interfacing with Programmable Logic Controller (PLC).

Technical Particulars

a) General:

Service	:	As per Process requirement
Installation hardware and accessories	:	Required
Type	:	Microprocessor based

Mounting	:	Front facia of Instrument Control Panel(ICP)
No. of channels	:	16 / 24- channels, As required with 20 % Spare.
Quantity	:	As per Process Requirement.
Input	:	From Temperature measuring sensors
Display	:	Separate LCD/LED displays for channel no. and corresponding temperature
Auxillary Outputs (Relay's)	:	Two Nos. For each channel
Digit height	:	12.5 mm or higher
No. of digits	:	- 2 nos. for channel no. - 4 nos. (minimum) for process value display
Zero & Span adjustment	:	Required
Engineering units for display	:	Deg. Celsius
Accuracy	:	± 0.2 % of span or better
Weather protection class	:	IP-52 of IS 13947
Relay outputs	:	Required 2NO+2NC for each group
Communication port	:	RS-485 (With Modbus protocol) for interfacing with PLC

7.12.7 Analytical Instruments

General:

This section covers individual elements to measure and transmit pH and ORP. Transmitters shall convert the sensor measurement to a 4 to 20 mA dc signal capable of transmission into at least a 500 ohm load at 50 V or less. Power supply shall be 240 Vac, 50 Hz. Reference accuracy of the output signal shall be ± 1 percent of measured span or better. Output signal shall be electronically isolated from ground to permit connection to a receiver with a grounded input. Transmitters shall be provided with an indicating scale having at least a 0.1 meter calibrated length. Operating ambient temperature shall be -5 to + 50 degree C or better. Transmitted signals shall be linear with the measured variable excepting pH which shall be linear with pH.

Sensor Measurement Principles and Features: Each type of sensor shall use the measuring principle and incorporate the features appropriate to it as specified below:

pH and ORP sensors shall measure hydrogen ion activity and oxidation-reduction potential respectively in the process medium. The pH sensor shall consist of a glass measuring electrode, a reference electrode, a solution ground and a temperature sensor for compensation in the transmitter. The reference electrode shall be the non flowing type with an electrolyte diffusion rate through a non-reactive porous membrane or plug which shall not require electrolyte refill more often than once per year. ORP sensors shall use the same elements specified for pH sensors except that electrode shall be platinum and no temperature compensation is required. pH and ORP sensor assemblies shall incorporate an integrally mounted preamplifier for the measuring electrode.

Sensors shall operate over a temperature range of -,5 to + 1000 C or better.

Construction Transmitter and sensor enclosures shall be rated NEMA- 4(National Electrical Manufacturers Association) unless explosion proof (XP) is specified on the Schedule. Enclosure materials and finish shall be as specified in the Schedule. If not so specified, they may be the manufacturer's standard which is compatible with the corrosivity of the atmosphere normally in contact with the enclosure. All parts of sensors, their assemblies and supporting parts which are wetted by the process medium shall be constructed of stainless steel and/or plastic unless specified otherwise on the Schedule. When specified on the Schedule, pH and ORP assemblies shall be provided with integrally mounted ultrasonic cleaners.

7.12.8 Total Dissolved Oxygen Monitoring System

The Dissolved Oxygen (D.O) monitoring system shall consist of a sensor, transmitter, indicating converter and electrode cleaning equipment. Accuracy shall be + 0.5% full scale for DO, barometric pressure + 0.27 kPa and temperature + 0.3°C.

The sensor shall not require zero point calibration and shall last approximately 2 years with a DO level of 3-5 mg/l and 3-5 years with a DO level of 1-2 mg/l. The transmitter shall allow the DO sensor to be fitted without the use of tools. The transmitter shall output a signal proportional to the DO level and measured temperature. The following alarms shall be detected and transmitted.

1) Membrane puncture
2) Depleted or worn out DO sensor
3) System/electronic fault.

The indicating converter shall perform auto calibration of the system and compensate for sensor age, temperature, barometric pressure, relative humidity and liquid salinity. It shall display OD concentration, temperature, sensor lifetime remaining (mg/l x hours or %) and rh selected for calibration.

Construction. The DO sensor shall consist of a prefabricated, disposable, sealed cartridge that slides easily into the transmitter without special tools. Systems that require re-generation (refill of electrolyte and membrane change) will not be acceptable. The sensor shall use the Clark‘s principle, with a gold cathode, silver wire anode and a non toxic electrolyte of potassium chloride. The prestressed membrane shall be of Teflon and bonded onto the DO sensor.

The transmitter shall be protected to IP 67 and supplied with 6m of cable for connection to a junction box. The converter shall be housed in a NEMA 4 x enclosure and be handrail or panel mounted up to 200m from the sensor without need for a pre-amplifier. It shall be interchangeable without the need for recalibration or

reprogramming of the system by using a sensor specific storing device continuing all settings and calibration.

The sensor and transmitter shall be installed in a self cleaning polystyrene ball float, which shall float on the surface of the water and allow the sensor to be inserted by approximately 125mm into the water. The ball shall be constructed to fit the sensor and transmitter and leave a smooth surface to prevent accumulation of dirt or grease. Constructions where the sensor protrudes will not be acceptable.

7.12.9 Surge Protection Devices

Surge protection devices (SPDs) shall be suitable for withstanding the surge arising out of high energy static discharge / lightning strikes and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like Tranzorb, zener diodes, varistors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPD shall be self resetting to minimise the down time of the measurement loop.
SPD s shall be provided to protect devices transmitting and receiving analogue and digital signals derived from field devices located outdoors.
The surge protection device shall be rated for surge rating of 10 KA.

7.13 Programmable Logic Controllers

7.13.1 General

Programmable Logic Controllers (PLC) shall be provided as a Hot Stand-by Controller to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules, communication interface modules and Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications.

PLC's shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be _off').

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

PLC shall be of an approved type from a major international manufacturer.

PLC System (Panel) should be housed in a dust free environment.

7.13.2 PLC Coding

The Contractor shall supply, install, program and commission the PLC using the PLC manufacturers recommended windows based PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation. PLC shall be coded using FBD language.

The Contractor shall provide a suitable PC complete with PLC coding and documentation software as specified in the bid document & as agreed with the Employer representative based on the FDS submitted.

7.14 SCADA

7.14.1 General

The SCADA shall be suitable for day to day operation by non-computer literate personnel in the monitoring and operation of the treatment works.

7.14.2 SCADA

SCADA) shall be provided at central monitoring Room, which shall be based in the administration building.

The SCADA system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring and controlling all important system parameters and providing facilities for plant optimisation. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers workstation (EW), after successful log-on by security password.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

The HMI shall be constructed to a high standard to provide a high profile feature and focal point for visitors to the Sewage Treatment Plant (STP).

SCADA system should be housed in an **air-conditioned environment**.

7.14.3 Uninterruptible Power Supply (UPS)

The power for Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA/HMI) shall be derived from separate UPS. The central PLC based SCADA system and all the remote I/O systems shall be powered by UPS. This shall also include corresponding managed Ethernet switches, internal and external communication systems, monitors and LCD screens.

The UPS provided shall be sized to provide sufficient power to maintain system functioning for a period of minimum **1 hour,** in case of power failure.

The above feature should be demonstrated during Factory Acceptance Test (FAT) & Site Acceptance Test (SAT).

END of PART-7

PART 8

GENERAL MECHANICAL REQUIREMENT

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PART 8

8 GENERAL MECHANICAL REQUIREMENTS

8.1 Wet Wells

(a) In order to prevent surcharging of sewers, the maximum level of sewage in the suction/wet well shall be limited to 300 mm below the invert of the lowest incoming sewer.

(b) In order to prevent sewage from turning septic, maximum retention of sewage in the wet / suction well shall not exceed 30 minutes for the average flow.

(c) The depth of sump shall be such that it provides at least 15 % margin over the minimum required pump submergence calculated at duty point on the basis of the Hydraulic Institute Standard.

(d) The wet well effective operating volume (volume between low level where all pumps are shut off and high level where all pumps except standby are operating) shall be such that the hydraulic retention time in this volume at peak flow is not less than 5 minutes and the number of starts per hour does not exceed 6 for any single pump under any circumstances.

(e) Appropriate baffles shall be provided in the wet/suction well to prevent the excessive turbulence and air entrainment when free fall of material to be pumped occurs.

(f) Benching shall be provided at the bottom of the wet well towards the suction bell mouth to ensure that the pumps can be used to completely drain the wet well.

(g) The wet well design shall incorporate corner fillets and ogees as appropriate to eliminate dead spots, prevent accumulation of solids or debris, and to ensure that the wet well is fully self cleaning – automatically cleaned by the hydraulics of the flow.

(h) Priming of pumps shall be ensured by providing positive suction head.

(i) Operation of sewage pumps shall be automatic based on the sewage levels in the wet well.

(j) Standby unit of each type and size of pump employed shall be provided as specified in particular mechanical requirement and these shall be minimum requirement.

(k) The clearance between pumps outer periphery shall be not less than 1000 mm.

(l) Sequence of operation of raw sewage pumps shall be changed every 8 hours to avoid accumulation of solids in the wet/suction well.

(m) + 5% margin on the pump capacity shall be provided for all the pumps.

(n) The total head of the pump shall be selected considering peak flow and maximum design level in the wet well for normal conditions of operation, and checked for satisfactory operation under extreme conditions of operation; the selected head to be revised if required.

(o) The minimum permissible velocity in the pumping mains shall be 0.8 m/sec. The maximum velocity in the pumping main shall not exceed 2 m/sec.

(p) All dry/wet well pumping stations shall be provided with a pit and drain pumps with rigid DI piping (1 working + 1 standby) to automatically empty the stuffing box drain.

(q) Ventilation shall be provided for all the pumping station based on 15 air changes per hour.

(r) For SPS, mechanical rake coarse bar screen shall be provided upstream of the pumping station wet well. Provisions shall be made to allow lifting of screenings by belt conveyor.

(s) Appropriate lifting devices shall be provided for safe and easy retrieval and/or removal of the pumps from wet well or dry well for maintenance or any other purpose at all pumping stations.

(t) On the Common header of SPS and all pumping system shall be provided with Motorised Knife Gate Valve on upstream of Flowmeter and Swing Check Valve on downstream side.

8.2 Submersible Pumps

8.2.1 General

(a) Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, and single stage type.

(b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.

(c) Double Mechanical seals (back to back) shall be provided to protect the motor from ingress of sewage along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon-carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. . Seals must be capable of withstanding rotation in either direction. A detector shall indicate when moisture is leaking past the first seal.

(d) Impeller shall be non-clog enclosed type with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials.

(e) The critical speed of the rotor shall be at least 30% above the operating speed.

(f) Pump-sets shall have double bearings. Bearings shall be of the anti-friction type. Bearings shall be capable of taking the static weight of the rotating parts and any thrust generated by the operation of the pump. The bearing life shall be minimum 40,000 hrs of operation.

(g) Each pump shall be complete with a cast iron delivery connection arrangement for fixing to the concrete floor of the suction well. The joint between the pump discharge flange and the delivery piping shall be made by merely lowering the pump into guide rails / rope from access level. It shall be provided with all necessary fixings for guiding the pumps during lifting/lowering. Each pump shall be provided with a SS 316 lifting chain conforming to BS 1663 and BS 4942.

(h) Each pump shall be provided with an automatic coupling device for attaching to the duck foot bend base at low level by using lifting chain SS 316 and guide rail SS 316, even whilst the pump is submerged, without the need for personnel to enter the well. This automatic coupling device shall easily and automatically couple and uncouple from the duck foot bend base and be complete with necessary accessories. All links and cables shall be multi-stranded stainless steel.

(i) The materials of construction for submersible pumps shall be as follows :

8.2.2 Features of Construction

(a) Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, and single stage type.

(b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.

(c) Double Mechanical seals (back to back) shall be provided to protect the motor from ingress of sewage along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon-carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. . Seals must be capable of withstanding rotation in either direction. A detector shall indicate when moisture is leaking past the first seal.

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(i) The materials of construction for submersible pumps shall be as follows :

S. No.	Component	Material
(i)	Impeller *	Stainless Steel : ASTM A 743 CF8M
(ii)	Casing *	Cast Iron to IS:210 Gr FG 200
(iii)	Mechanical seal (Motor side and Pump side)*	oil-lubricated with tungsten carbide or silicon-carbide faces
(iv)	Shaft*	Stainless Steel : BS:970 Gr 431
(v)	Bush*	Bronze IS 318 Gr. LT B2
(vi)	Guide rail pipe #	Stainless Steel : BS:970 Gr 316
(vii)	Lifting Chain	Stainless Steel : AISI 316
(viii)	Fasteners and Foundation Bolts	Stainless Steel AISI 316

* Material test certificates from Government approved metallurgical laboratory shall be furnished by the Contractor

For tube installed pumps the tube and guide wire material shall be of SS 316 grade.

(j) Each pump shall be tested at the manufacturers premises for the full operating range of the pump to BS 5316 Part 1 .Pump performance shall be within the tolerance limits specified in the above said BS.

8.3 Chemical Feeding Equipment

8.3.1 Chemical Dosing Pumps

(a) Chemical dosing pumps shall be piston, piston diaphragm or mechanical diaphragm type as specified. Pumps may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined baseplate.

(b) Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self cleaning action. Ball and seat materials shall be resistant to abrasion.

(c) Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving stepless adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

(d) The normal operating range of dosing pump shall be not less than 6:1.

(I)	Mechanical Diaphragm	Diaphragm rigidly coupled to the drive train. Single suction Pumps and discharge valves. Glandless. Accuracy: ± 3% of stoke.
(II)	Piston Pumps	Cylinder and piston with packed gland. Double suction and discharge valves can be fitted for greater accuracy at high pressure. Accuracy: ± 1% of stroke.
(III)	Piston Diaphragm Pumps	Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: ± 2% of stroke.

Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.

(e) Each pump shall be provided with inlet and outlet isolating valves and with pressure relief and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines.

(f) A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected. Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

(g) Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

(h) Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. The gear box shall incorporate the cams for the diaphragm drive and shall be provided with filling and drain connections and visible oil level indication.

(i) All dosing pumps shall have facility/terminals for pulse input & output (4-20 mA) to facilitate online control via plant PLC & SCADA.

8.3.2 Chemical Tank and Mixer

(i) General

This tank shall be used to dissolve the alum or polymer to a constant concentration and feed the solution to the outlet channel of the aeration tank or the dewatering equipment. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, electrical level gauges, direct reading level gage, ladder, air exhaust pipe etc.

(ii) Fabrication

(a) The tank shall be made of corrosion resistant material.

(b) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.

(c) The tank shall be provided with necessary mounting seats for overflow pipe, etc.

(d) The motor-driven mixer shall be vertical speed reducer, direct-coupled type of 2-stage propeller type, as a rule and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the center or at a position off the center according as the tank being angular or circular.

(e) The mixer shall be protected by electrical prevention of dry operation.

(f) The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.

(g) Alum feed cage of stainless steel shall be provided inside the alum solution tank.

(iii) Materials

(a)	Main Tank body	:	GRP/HPDE or equivalent
(b)	Mixer frame	:	SS316
(c)	Mixer shaft	:	SS316
(d)	Blade	:	SS316L

(iv) Accessories (per Unit)

(a) Foundation bolt and nut x 1 set
(b) Air vent pipe x 1 set
(c) Mixer x 1 unit
(d) Direct reading level gauge x 1 unit

8.3.3 Alum Dispersion Rapid Mixer

(a) The alum dispersion rapid mixer shall be in-channel submersible chemical vacuum induction unit and consist of chemical induction unit with mount bracket, guide rail assembly, floor mount base, boom hoist with manual brake winch and SS 316 cable, hose assembly, control panel and submersible power cable.

(b) The unit shall be provided instantaneous diffusion / mixing and the highest level of durability and performance required for chemical feed application.

(c) The hermetically sealed SS 316 motor shall provide the highest level of durability and performance required for chemical feed applications. All wetted materials shall be constructed from Grade 2 Titanium (unalloyed) and shall be designed for use with all common water and wastewater treatment chemicals. The mounting bracket shall be engineered for installing in open-channel applications.

(d) The material of construction of chemical induction shall be as follows:

S. No.	Component	Material
(i)	Vacuum chamber	Titanium
(ii)	Vacuum port	Titanium
(iii)	Vacuum enhancer	Non-metallic
(iv)	Propeller	Titanium
(v)	Propeller bolt	Titanium
(vi)	Shaft	Titanium
(vii)	Mechanical seals	Carbon /ceramic
(viii)	Hardware	SS 316

8.4 Induction Motor (Sludge Pumps)

8.4.1 Design Requirements

The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply.

The motors shall generally conform to IS: 325 or relevant equivalent internationally approved standards. Additionally the specific requirements mentioned in the following clauses shall also be met. All motors shall be EFF-1 energy efficient type.

8.4.2 Performance and Characteristics

(a) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

(i) Variation in supply voltage + 10%
(i i) Variation in supply frequency + 5%
(i i i) Combined voltage and frequency variation ⍰10%

(b) Motors shall be suitable for full voltage direct-on-line starting or star delta starting. Minimum permissible starting voltage shall be 85% of the rated voltage.

(c) The Power rating of the motor shall be the larger of the following :

(i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 49 Hz.
(ii) Maximum power input while operating single pump corresponding to the speed of 50 Hz.

8.4.3 Insulations

Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation. The degree of enclosure protection of motors shall be of minimum IP 55.

Motors shall be given power house treatment. This comprises an additional treatment to the winding over and above the normal specified treatment. After the coils are placed in slots and all connections have been made, the entire motor assembly shall be impregnated by completely submerging in suitable insulating compound or varnish followed by proper baking. At least three such submersions and backings shall be applied to the assembly.

8.4.4 Constructional Features

The motor construction shall be suitable for easy disassembly and reassembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

a) Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
b) The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

8.4.5 Terminal Box

Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.

The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied to match specified cables.

Separate terminal boxes shall be provided for the following:

(i) Starter leads; and
(ii) Space heater

8.4.6 Accessories

Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

8.4.7 Heating during Idle Period

For motors rated below 30 kW, during idle periods, the stator winding will be connected to required single phase, 50 Hz, AC supply for heating and elimination of moisture. The supply will be connected between any two terminals.

Motors rated 30kW and above shall have space heaters suitable for 230V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

8.4.8 Earthing Pad

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides complete with suitable bolt and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

8.4.9 Rating Plate

The following details, in addition to those specified in applicable standards shall be included on the rating plate.

Rated voltage, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.

Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity.

8.4.10 Tests

Motor shall be subjected to all the type test (one from similar rating of each lot) and routine tests as per applicable standard in the presence of the Engineer. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Employer‟s approval. The Contractor shall ensure to use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to National / International standards.

8.4.11 Low Voltage Motors

Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85% of the rated motor voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard).

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

Motors rated 30 kW and above shall be provided with space heaters with adequate capacity to maintain motor temperature to prevent moisture condensation on the insulation during idle condition. The space heaters shall be suitable for 240V single phase 50 Hz supply. The degree of enclosure protection of motors shall be of minimum IP 55.

8.5 HV Motor (For Process Air Blowers)

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 80% of the rated voltage.

(a) Motors shall be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.

(b) The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than starting time at minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. The locked rotor current of motors shall not exceed 600% of full load current of motors which is inclusive of 20% tolerance.

(c) Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive starts from cold condition and one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

(d) The three phases shall be segregated by metal barriers within both line and neutral terminal box.

(e) The earthling pads shall be of non-corrodible metal, welded/brazed at two locations on opposite sides. The pad size shall be 75 x 65 x 25 mm with two holes drilled at 40mm centers, tapped & provided with suitable bolts and washers for connecting the earthling strip.

(f) At least six resistance type temperature detectors for the stator winding each having D.C. resistance of 100 ohms at 0 degrees Celsius, embedded in the stator winding at locations where highest temperatures may be expected, shall be provided. The material of the RTD's shall be platinum.

(g) At least one vibration detector for the stator winding, embedded in the stator winding at location where vibration may be expected, shall be provided. Compression-type piezoelectric type accelerometers, velocity transducers or proximity transducers shall be applied to the vibration detection system.

(h) Motors shall have space heaters suitable for 240V single phase 50Hz AC supply. These shall be placed in easily accessible position in the lower part of motor frame. Provision shall be made to measure temperature of bearing by inserting hand held temperature measuring device.

(i) Motors shall have drain plugs so located that they will drain water, resulting from condensation or other causes from all pockets in the motor casing.

Data:

Sr. No.	Description	Unit	Particulars	
(a)	Type of motors (Main Motor)		Squirrel Cage	
(b)	Supply System fault level 6.6KV	MVA	143	
(c)	Rated Voltage	KV	3.3	
(d)	No. of Phases and frequency		3 Phase, 49 Hz	
(e)	Type of duty/designation		Continuous/S1	
(f)	Method of Starting		Using VFD	
(g)	Class of insulation		F	
(h)	Ambient reference temperature	deg. C	40	
(i)	Temperature rise shall be limited to Class B Thermometer Winding resistance	 deg. C deg. C	 70 80	
(j)	Location		Indoor	Outdoor
(k)	Type of Cooling (IS:6362)		TEFC	TEFC
(l)	Degree of Protection		IP55	IP65

Sr. No.	Description	Unit	Particulars
(m)	Terminations		
	(i) Short time current withstand for terminal box	kA(rms)	25
	(ii) Duration	Sec	1
	(iii) Dynamic current withstand for terminal box	kA(peak)	31
	(iv) External cable details • Type		3.3KV, UE, Al. Cond. XLPE
	(v) Earthing Conductors • Material • Size	 mmxmm/ SWG	 GI Main motor – 50 x 10
(n)	Colour shade of paint		Light grey, Semiglossy Shade: 631 of IS: 5

8.6 Induction Motor (Submersible Pump)

8.6.1 Performance and Characteristics

a) The submersible motor shall conform to IS: 9283:1979 and the submersible cable shall conform to clause no. 4.4 of the IS: 9283:1979. The motors shall be suitable for operating on a 415 V, 50 Hz, 3 phase, Ac supply. Pump motor shall be of the squirrel cage submersible type; protected to IP 68.Motor for submersible pump shall be capable of start up and operation in the event of a completely flooded wet well. Motor cooling for submersible pump must be achieved by a cooling jacket, using the pumped media to cool the motor. The pump impeller must be equipped with a system to ensure a pumped flow of liquid through the cooling jacket and also incorporate a device to prevent the liquid channels from blocking with hair and foreign material. This motor shall be capable of starting 10 times per hour. The insulation class of motor winding shall conform to class F .Additionally the specific requirements mentioned in the following clauses shall also be met. The motor shall be of Eff-2 energy efficient type.

b) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions :

(i) Variation of supply voltage from rated motor voltage ±10%
(ii) Variation of supply frequency from rated frequency ±5%
(iii) Combined voltage and frequency variation ±10%

The starting current of motor shall not exceed 300% of rated full load current for soft starter starting and 600% of rated full load current for DOL starting, under any circumstances.

Motors shall be suitable for full voltage direct-on-line starting or soft starter starting.

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard) unless otherwise specified.

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation. The motor vibrations shall be within the
limits specified in applicable standard unless otherwise specified for the driven equipment.

Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283-1979.

Motor insulation shall conform to Class F and the maximum temperature rise shall be limited to class B. The motor windings shall be protected with a waterproof material and shall incorporate a thermal sensor in each phase to safe guard against high winding temperatures. The thermal sensor shall be connected into the control circuit of the starter and signals taken for continuous monitoring of winding temperatures. The motor shall incorporate a cut out device to detect the presence of any liquid in the motor enclosure, in the form of non resetting moisture switch. The terminal connections for the power and protective circuits shall be housed in a completely sealed and water proof junction box, complete with all external corrosion resistant cable glands. The pump units shall be provided with power and protection circuit cables of sufficient length to reach from the motor junction box to the local isolator located at the panel floor level.

Protection against increase in stator winding temperature bearing temperature, leakage in stator housing and terminal box shall be provided. Minimum three number thermistors are to be provided to sense the stator winding temperature. Sensors are to be provided to detect if leakage of sewage into the oil housing is above 30 % concentration.

Bimetallic thermal switch to trip the motor against increase in temperature shall be provided. The

power rating of the motor shall be larger of the following:

(i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 49 Hz.

(ii) Maximum Power input while operating single pump corresponding to the speed of 50 Hz.

Motor shall be offered for routine and type tests in accordance with IS: 4029 and IS: 325 at the manufacturer's works.

8.6.2 Submersible Cable

(a) The submersible cable shall conform to clause no. 4.4 of the IS: 9283:1979.The power cable shall be PVC insulated and PVC sheathed, flexible, 3.5 core flat type. The size of the conductor shall be adequate for continuous use under water and air. The half core shall be used for earthing.

(b) The control cable shall be PVC insulated PVC sheathed, flexible, flat type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor (Thermistors) 3 core x 2.5 sq. mm copper conductor and for bimetallic thermal switch 2 core x 2.5 sq. mm copper conductor shall be provided.

(c) In case a joint is required to be made between the lead cable supplied with the motor and the user's cable connectors, a detailed procedure of cable jointing to make a watertight joint shall be provided by the manufacturer.

(d) The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

8.6.3 Earthing

Earthing of the motor shall be done in accordance with the relevant provisions of IS: 3043:1966. For the purpose of earthing these motors, earthing connection may be made to discharge pipe.

8.6.4 Insulation

(a) Any joints in the motor insulation such as at coil connections or between slot and end winding sections, shall have strength equivalent to that of the slot sections of the coil.

(b) The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropicalising treatment shall be as per the applicable standard.

(c) The stator winding shall be made from high conductivity annealed copper conductor, PVC insulated winding wires conforming to IS: 8783:1978 for wet type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII):1970 for dry type motors.

8.6.5 Temperature Rise

The temperature-rise test of the motor shall be carried out with the motor coupled to the suitable pump as per relevant standard.

8.6.6 Constructional Features

The motor shall be suitable for continuous use in fully or partially submerged condition. A built in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not, by providing either external or internal cooling arrangement.

8.6.7 Terminal Box

Terminal box shall be of weather proof construction to eliminate entry of water and dust.

The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearance.

8.7 Gate –controlled Weir

These Gates are downward opening type and shall be used for flow splitting, Decanting of reservoir or a tank OR For maintaining precise level control in a reservoir or a tank.

The gates shall have minimum following features:

a. Suitable for seating and unseating Head
b. Flange /Flat back frame design
c. Metal to Metal sealing on 3 sides
d. Manual lift mechanism to enable single person operation with effort not to exceed 20 Kgs.

The material of construction of Gate –controlled Weir shall be complied with “8.9 Sluice Gate”.

8.8 Sluice Gate

8.8.1 Cast Iron Gate:

(a) Design Requirements and Construction Features

The construction of sluice gates shall be in accordance with the specification and generally as per IS: 13349. All sluice gates shall be of the rising spindle type.

(b) Frame

The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

(c) Seating Faces

Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.

(d) Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing contact between the slide and frame facing when the gate is in closed position.

(e) Lifting Mechanism

(i) Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required, to keep the torque requirement within 7 kg.m.

(ii) Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.

(iii) Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.

(f) Wall Thimbles

The cross section of the thimble shall have the shape of the letter 'F'.

(g) Lifting Lugs

Lifting lugs shall be provided for all gates.

(h) Flush Bottom Seal

(i) When sluice gates are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.

(ii) A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slide is closed.

3 Nos. of Portable type of electric actuator for closing and opening of sluice gates shall be provided at STP including SPS, so that the closing and opening operation time shall be maximum of 10 minutes and similarly.

(i) Suitable arrangement shall be made on all the sluice gates or actuators such that the actuator is capable of operating all sizes of sluice gate, under this contract.

(j) The material of construction of sluice Gate shall be as follows:

S. No.	Component	Material
(i)	Wall Thimble	Cast Iron : IS 210 Gr. FG 200
(ii)	Frame and Slide	Cast Iron : IS 210 Gr. FG 200
(iii)	Seating faces	Stainless Steel : ASTM Countersunk fixing A276 type 316
(iv)	Wedge	Stainless Steel : ASTM A743 CF8M or SS316
(v)	Stem	Stainless Steel: ASTM extension A276 type 316
(vi)	Stem nut	Stainless Steel : ASTM A743 CF8M
(vii)	Stem Coupling	Stainless Steel : ASTM A276 type 316
(viii)	Fasteners, anchor	Stainless Steel : ASTM bolts and nuts A276 type 316
(ix)	Lifting mechanism, Pedestal gear house cover and stem guide	Cast Iron : IS 210 Grade FG 200
(x)	Lift nut	Bronze : ASTM B 148 (CA952, CA954 or CA958)

8.8.2 Modulating Sluice Gate

It shall be as per IS: 13349-1992.

Wall thimble mounted Sluice gates shall be used for isolation of flow from a chamber to a closed conduit. It shall be suitable for modulation application.

Salient Features

- It shall be of flange back frame gate suitable for mounting on the face of a Cast iron Wall thimble using studs and with a gasket between gate frame and wall thimble flange.

Wall thimble shall have cross section "F" and depth of 300 mm. Gates having square / rectangular opening to be provided with thimble having square/ rectangular opening aperture with square / rectangular flange for gate frame mounting.

- It shall have Square/Rectangular shaped natural rubber Gasket with predrilled holes for positioning in between machined face of wall thimble flange and frame flange.

- It shall have open top frame provided with short length extension guides to support $^{1}/_{2}$ vertical height of the slide when the slide is in full open position.

- Frame will be provided with liners for modulating duty application.

- Frame specially designed to permit front access for tightening of thimble mounting nuts so as to enable mounting of gates side by side or near corners.

- Rigid shutter designed to withstand the applicable water head. Shutter to be provided with cast integral pocket to house the stem-connecting block, which connects the spindle to the shutter for up and down operation.

- Seat facing fitted on machined plain surface of frame and shutter-using counter sunk screws for better fitments.

- The type of bottom closing offered is Flush bottom closing (FBC). In flush bottom closure gates, sealing to be metal to rubber for bottom side and metal-to-metal on balance three sides.

- Adjustable type individual side wedging arrangement for gates meant for seating water head application and adjustable type individual side as well as top & bottom wedging arrangement for gates meant for unseating water head application.

- Adjustable Channel type stem guide brackets in requisite quantity to prevent buckling of spindle in event of over-closing of gate.

- Rising stem / spindle to suit the distance between centerline of gate opening and top of operating platform as stated below in price schedule. The spindle shall be provided with square / trapezoidal threading with the threaded length being approximately 400mm more than the height of waterway opening.

- Spindle couplings to connect multiple stem / spindles in case the maximum length of one-piece stem / spindle exceeds 4.5 to 5 meters resulting into provision of more than one stem / spindle.

- Rising spindles are provided with Stem cover of Polycarbonate tube to protect spindle threads from effect of dust, dirt and weather.

- Rising spindles are provided with gate opening indicating arrangement to indicate the position of shutter.

- Provision of safety stop nut on spindle to prevent the chances of over-closing of gate, which may otherwise damage either the spindle or the lifting platform.

- Lift mechanism mounted on separate platform above gate frame so that gate operating thrust comes on to the platform.

- Operation of gate by means of electric lift mechanism comprise of pillar mounted Electric Actuator with manual override unit. These actuators should have an inbuilt with local control push buttons and suitable for modulating application.

SI.No.	Part Description	Materials of Construction
a	Frame & Shutter	CI IS: 210 Gr. FG 200
b	Wall Thimble	CI IS: 210 Gr. FG 200
c	Seating Faces & Counter Sunk Fixing	Stainless Steel ASTM A240 type 304
d	Wedging Device (with SS 304 Linings)	CI IS: 210 Gr. FG 200
e	Stem, Stem Extension & Coupling	Stainless Steel ASTM A276 type 304
f	Stem Block	Stainless Steel ASTM A743 CF8
g	Fasteners, Anchor Bolt, Studs & Nuts	Stainless Steel ASTM A276 type 304
h	Lifting Mechanism, Pillar, Head Stock	CI IS: 210 Gr. FG 200
i	Stem Guide	CI IS: 210 Gr. FG 200
j	Stem Guide Bracket	Structural steel
k	Stem cover with Indicating Arrangement	Polycarbonate Tube
l	Lift Nut	Bronze IS: 318 Type LTB-2

8.9 Mechanical Coarse Bar Screen

8.9.1 General

(a) The screen shall be installed in raw sewage inlet channel, and the screen shall be of the front raking type. Inclined Bar screen at 75 degree and the minimum bar thickness shall be 10/ 15 mm.

(b) The screen shall be capable of performing the duties set out in this Specification. All the materials and sub-assemblies used shall be suitable for outdoor application. They shall be constructed so that maintenance is kept to a minimum.

(c) Ideally, any moving parts such as sprocket, bearings, etc should not be in immersed in sewage. In case immersed, the parts shall be of such materials that they require little or no maintenance. All lubricating points shall be conveniently accessible from the deck level.

(d) The screen shall be suitable for discharging 75% of the screened material lifted from the screen into the chute.

(e) The screen shall be designed such that in case of heavy accumulation of solids the same is to be removed gradually without overloading or damaging the screen bars or mechanism.

8.9.2 Frame work

The frame work of the screen shall be of robust construction with intermediate cross bracing. The lower ends and sides of the frame shall be grouted in concrete. Each screen shall have an independent canopy at the top for weather protection.

8.9.3 Screen bar assembly

Screen bar assembly shall be fitted across the screen chamber. Screen shall have a series of vertically oriented bars spanning the inlet channel and spaced as specified. Bars shall be sufficiently rigid to prevent vibrations in stream-wise and lateral modes and to withstand the maximum differential head that will occur with the screen totally blinded. Bars shall have tapered cross section to prevent jamming of screenings between bars. Bars shall have supports only at both ends.

8.9.4 Rake carriage

(a) The design shall be multirake and the rake carriages shall comprise a stiffened frame work to which is attached replaceable rake tines. The rake tines shall be suitable to accommodate bulky screenings. Rake carriage shall incorporate suitable devices to enable the rake to ride over any small obstacles wedged in the screen and automatically stop the drive motor in the event of the rake jamming against a large obstruction. There shall not be any mechanical damage resulting

from obstruction wedged in the screen bars. The rake carriage shall always come to rest in a parked position with the rake above the sewage level.

(b) The screen shall be cleaned automatically through an adjustable timer. The rake lowered will clear screen bars at the beginning of a cycle and accurately engage with the screen bars at the bottom of the channel. The tine profile and rake motion shall be designed to elevate screenings to the discharge chute at deck level without debris falling back or being forced through the screen. The rake shall be suitable for levating debris encountered at any level. Rake tines shall be replaceable.

(c) The screenings shall be discharged from the unit by a wiper mechanism down to a discharge chute leading to a conveyor belt. Arrangement shall be such as to ensure that screenings are discharged to the discharge chute leading to the conveyor. The rake tines shall then be retracted and the unit ready for the next cycle.

8.9.5 Rake Lifting Mechanism

Lifting mechanism shall consist of a SS 316L wire rope or chain and SS 316 sprocket.

8.9.6 Inspection Platforms

An inspection platform shall be provided for periodic checking and maintenance of the drive and other critical parts. A ladder with handrails for access to this platform shall be fixed. Suitable hand rails shall be provided for safety on the inspection platform and also at deck level.

8.9.7 Dead plate

SS316L dead plate extending from the top of the bars to the deck level shall be provided to ensure that screenings do not fall back. Dead plate shall be made of minimum 5 mm thick plate. The clearance between the tines and the dead plate shall not exceed 5 mm.

8.9.8 Driving Mechanism

The driving mechanism shall consist of a sturdy reduction gear unit driven through multiple 'V' belts or directly by an electric motor. Motor shall be mounted in such a way that the tension of the 'V' belts can be adjusted. A manually reset torque limiter shall be provided between the motor and gear unit, incorporating a limit switch to cut off the supply to motors in the event of an overload.

8.9.9 Gear Reducer

(a) The reducer shall be sized and selected with a minimum service factor of 2.0 times the motor nameplate horse power rating in accordance with applicable American Gear Manufacturer's Association Standards. The reducer shall have a life of 40,000 hours based on the motor name plate

horse-power. The reducer shall have an efficiency of not less than 90% based on reducer input.

(b) All gear meshes shall be oil lubricated. All gears shall be provided with an oil reservoir for instant lubrication on starting. The gear reducer housing shall be provided with an oil level indicator and oil drain with necessary fittings.

(c) The gear reducer shall be of cast iron construction. The reducer housing shall also include suitable lifting lugs and external gear train inspection covers for each gear train. The gears shall be matched for maximum tolerance variation. The gear reducer shall be suitable to reduce the motor asynchronous speed to achieve the required speed of raking.

8.9.10 Control System

(a) The screening operation shall be carried out through adjustable timers which are adjustable at site for 0-60 minutes for interval between two operations.

(b) Control system for the conveyor shall be designed to achieve the following:

(i) Conveyor shall be started when any of the rakes starts it‟s upwards travel.

(ii) Conveyor shall be stopped with a time delay (by adjustable timer) after rake is stopped.

(c) Weatherproof, lockable, emergency mushroom headed stop push buttons shall be provided near each motor for screen and conveyor belt, operation of stop push button, and overload prevention for screen and belt conveyor shall be included in the control scheme.

8.9.11 Conveyor System

(a) For the disposal of screenings, a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads.

(b) The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of 20 deg. trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti-friction bearings.

(c) The belt material shall be two poly nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer

shell shall be counterbored and a full length centre tube journalled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.

(d) The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.

(e) Shafting for pulleys shall be of heat treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.

(f) The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.

(g) The conveyor shall be supported on 150mm channel sections with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy.

(h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fibreglass/fibre reinforced plastic.

(i) Screenings discharge chutes shall be provided to transfer screenings from the screens to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials.

(j) The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. belts way switches shall be provided on conveyor.

8.9.12 Portable Screenings Container

Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up. The container shall have capacity of approximate 2.0 cu.m and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The containers shall have hinged covers and their design shall permit their being lifted by an overhead hoist or packer truck. The container will have four wheels each of about 20 cm diameter and two of which shall be swivel castors. The maximum height of container including wheels shall be 66 cms. The sides shall be constructed of 12 gauge steel. The bottom of container shall be made of 5 mm plate steel. The containers shall be reinforced with 50 mm x 50 mm x 5 mm angle.

8.9.13 Automatic Jam removal system

The screen shall have automatic electronically controlled Jam removal facility to ensure smooth operation.

8.9.14 Motors

(a) Motors shall be squirrel cage type conforming to IS 325. The power rating of motor shall be at least 125% of maximum power requirement. The other features of motors shall be as follows :

(i)	Type of duty	:	Intermittent (S4)
(ii)	Method of Starting	:	DOL
(iii)	Class of insulation	:	F (Temperature rise limited to class B)
(iii)	Type of enclosure	:	TEFC
(iv)	Degree of protection	:	IP 55

(b) The material of construction of Mechanical Raked Screen shall be as follows :

S. No.	Component	Material
(i)	Screen	Stainless steel SS316L
(ii)	Frame (Side and Bottom Portion)	Stainless steel SS316
(iii)	Raked tines	SS316L
(iv)	Fasteners including Anchor bolts	Stainless Steel : 316L
(v)	Screen canopy	Stainless Steel: SS316L
(vi)	Chutes	SS304

8.10 Mechanical Medium Bar Screen

The screen shall be installed in inlet channel to grit chamber, and the screen, shall consist of continuously moving perforated stainless steel panels. Inclined Bar screen at 75 degree and the minimum bar thickness shall be 8/ 12mm. The aperture size of the screen shall be 6 mm and shall be of tapered section. Other specification shall remain as per above clause 8.10.

8.10.1 Construction

(a) Frame :

The frame shall consist of two lateral stainless steel 316 L plates connected by means of cross braces.

(b) Chain wheels :

The machine shall work on the endless chain principle and incorporate chain wheels at the top and bottom. The top wheels shall be keyed onto the main drive shaft. The bottom wheels shall be carried on stub shafts incorporating a sealed bearing of suitable synthetic material.

(c) Chain :

The chain shall be constructed in stainless steel 316 with the screen panels directly attached.

(d) Screen Panels :

Screen panels of suitable thickness and SS 316L construction shall incorporate 6mm diameter perforations. These panels shall be carried on the chains. The panels shall be specially formed to give a very rigid construction and shall create steps to enable larger screenings to be removed.

(e) Seals :

Suitable sealing shall be incorporated at each side and across the bottom of the screen to prevent screenings from by-passing the screen panels.

(f) Screenings Discharge :

(i) Screenings shall be discharged on the downstream side on to a belt conveyor of the unit and shall be removed from the screen panels by a scrapper mechanism. The scrapper blade shall be made of synthetic or equivalent.

(ii) Screenings are delivered down an enclosed chute.

(iii) Two nos. Screening collection containers (wheeled) of suitable capacity shall be supplied with the screens.

(iv) The conveyor system and the screenings containers shall be similar to the items in clause 8.10.11 & 8.10.12 above.

(g) Raking Mechanism

The design shall of multirake type and shall be of all SS316 L construction. The rakes shall run in guides on both sides to ensure engagement and shall clean bars from upstream side of screen. The rakes shall be designed to prevent screenings from falling back to the channel.

(h) Dead Plate

The dead plate shall extend to point of discharge from rake to the chute and shall be SS316L. The dead plate shall be true flat such that a close clearance between raking tines and plate can be maintained during cleaning cycle. The back of dead plate shall be designed to ensure maximum gap between rake bar and dead plate leading to discharge chute.

(i) Enclosure

The entire assembly shall be enclosed in reinforced fiber glass housing. A hinged front cover shall be provided to give access to the rotating brush assembly and screen discharge area. A sliding inspection hatch shall also be incorporated.

(j) Drive Unit

(a) The drive to the main shaft shall be TEFC weatherproof IP55 motor fitted with an anti-condensation heater. The motor shall be flanged to a shaft mounted gear unit giving the final output speed. This shall produce a linear speed for the screen panels of about 3 m/min.

(b) The drive shall be protected from mechanical overload by an electrical current sensing device in the screen control panel.

(k) Overload prevention switches shall be provided to annunciate screen jamming.

(l) Suitable conveyer arrangement shall be provided to transfer the screenings to the nearest container/trailer.

(m) A spray system shall be provided to backwash the screen panels and to help in cleaning the screenings. Water / treated sewage shall be used for back wash purpose.

8.10.2 Automatic Jam removal system

The screen shall have automatic electronically controlled Jam removal facility to ensure smooth operation.

8.11 Automatic Drum screen

i) General

The automatic drum screen shall be composed of screen, screw conveyor, washing unit, dewatering unit and drive unit, etc. The automatic drum screen shall have 6 mm opening and shall be used to block, scrape, wash, and dewater the suspended solid or scum in the influent or sludge.

(ii) Design Condition

(a) This equipment shall be designed with sufficient safety factor in strength.

(b) This equipment shall be of integrated type and shall be constructed such that it can be installed easily.

(c) The difference of water level, the characteristics of suspended solid, and flow rate shall be considered in design.

(iii) Fabrication

(a) Drive unit

- Cycloidal reduction gear or worm reduction gear shall be used as drive unit. Drive unit shall transmit the power by means of gear transmission or direct connection with coupling.

- Gear box shall be provided in case of gear transmission.

(b) Screen

- The screen shall be made of cylindrical stainless steel. The screen shall have a smooth finish in order to prevent the attachment of screenings and shall be arranged with equal spacing.

- An electrical pole shall be installed in front of the screen in order to detect the overflow and control operation.

(c) Rake

- The rake shall be connected with the screw conveyor along the same axis and shall rotate with it. The raked screenings shall be scraped down into the screw conveyor by the scraper.

- The rake shall be constructed such that the screenings never remain on the screen after raking.

(d) Screw conveyor

- The impeller and shaft of the screw shall be a welded structure of stainless steel and shall endure the incurred stress.

- A dewatering device shall be provided at the upper portion of the screw conveyor. The dewatering device shall be sealed and shall have sufficient strength to endure the pressure of screenings and scum. The inspection hole and washing water pipe shall be provided for the dewatering device. The inspection hole shall permit easy inspection and the washing water pipe shall be used to wash the casing for filtrated liquid.

(e) Shaft and bearing

- The shaft of screw shall be made of stainless steel and shall have sufficient strength to endure the incurred stress.

- The submerged bearing shall be an oil-less enclosed pneumatic type. For a bearing installed above the water level, an automatic oiling device shall be provided.

(f) Washing unit

Washing nozzles shall be provided at the inlet of the screw conveyor in order to wash down the screening or scum with pressurized water.

(g) Chute

A stainless steel chute shall be provided at the discharge part of the screw conveyor. The chute shall be constructed such that the screenings are blocked from being discharged.

(iv) Materials for automatic drum screen

(a) Screen : Stainless Steel AISI316L

(b) Rake : Stainless Steel AISI316L

(c) Screwconveyor : Stainless Steel AISI316L

(d) Chute : Stainless Steel AISI316L

(v) Protection Equipment

(a) Mechanical protection

For cyclodial reduction gear, a built-in torque limiter shall be provided.

(b) Electrical protection

An over-current detector with instantaneous converter shall be provided in case the mechanical protection is not provided.

(vi) Accessories (per Unit)

Anchor bolts and nuts SS316 - 1 set

8.12 Manual Medium Bar Screen

(a) The screen shall be installed in inlet bypass channel to grit chamber.

(b) The aperture size of the screen shall be 10 mm and 50 angle of inclination.

(c) The screen shall be fabricated out of SS316 flats and fixing bolts shall be of stainless steel.

(d) The rectangular trash screens shall comprise galvanized M.S flats, 10 mm thick and 50 mm wide in section.

(e) The screen shall be rigidly fixed to the frame.

(f) All the bypass screens shall be provided with 2 sets of SS 304 cleaning rakes with appropriate grip handle.

8.13 Manually Operated Travelling Crane

8.13.1 Crane

(a) The crane shall be manually operated for return activated sludge pumping station.

(b) The capacity of crane shall be as per the equipment list in particular mechanical requirement and of class II.

(c) The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. Steel used shall be tested quality steel conforming to IS 2062.

(d) The long travel bridge wheels shall be rim toughened; heat treated galvanized carbon steel or low alloy steel or C.I. They shall be double flanged type. The wheels shall have antifriction ball/roller bearings. The wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied by the Contractor.

8.13.2 Trolley and Chain Pulley Block

(a) The chain pulley block shall be operated on the lower flange of the bridge girder.

(b) The load chain shall be made of alloy steel as per IS:3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.

(c) The hand chains, SS 316, for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. The hand chain wheel shall be made from pressed sheet steel and shall be provided with roller type guarding to prevent snagging and fouling of the chain.

(d) All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS 436/IS:4460.

(e) The trolley track wheels shall be rim toughened, heat treated carbon steel or low alloy steel or C.I. and shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.

(f) The travelling trolley frame shall be made of rolled steel conforming to IS:2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. The two side plates shall be connected by means of an equalizing pin.

(g) Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.

(h) The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. They shall be of single hook type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swiveling shall be provided. Hook shall be as per BS:2903/IS:3815

(i) The brake for the lifting gear shall be automatic and always in action. It shall be of screw and friction disc type self-actuating load pressure brake. Brakes shall offer no resistance during hoisting.

8.14 Electrically Operated Hoists

(a) Electric hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust-proof push button station, contractor panel, all wiring, limit switches, etc.

(b) Electric hoists shall conform to IS: 3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.

(c) Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.

(d) Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one piece gear section. Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 36 wires per strand with minimum ultimate tensile strength of 1.6 x 106 KN / Sq.m.

(e) Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.

(f) Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. Brake shall apply when either the motor controller or the main power switch is in "OFF" position or in the event of power failure/

(g) Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS:325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.

(h) The electric hoists shall be of Class II duty.

(i) 25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer"s works.

8.15 Hand Operated Hoists and Trolleys

(a) Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.

(b) Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S.1663/B.S.3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress – relieved welded steel construction.

(c) Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with B.S. 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S., 2525-32:1954.

(d) Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

(e) The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

8.16 Electrically Operated Overhead Travelling Crane

(a) The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall conform to BS 2573,IS:3177 or relevant internationally approved standards.

(b) The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing as is required along the full span length of the bridge girder. Steel shall be tested quality conforming to ASTM A36 except that, plates more than 20 mm thick shall conform to IS:2062,BS:4360 or relevant internationally approved standards.

(c) The bridge shall be designed to carry safely the loads specified in IS:807, BS:2573 or relevant internationally approved standards. All anti-friction bearings for bridge and trolley track wheels,

gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.

(d) Wheel base and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels

shall be of forged steel and shall be double flanged type. The wheel diameter and rail sizes shall be suitable for the wheel loads.

(e) The crane rails shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

(f) All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100000 hours. Electro-magnetic and hydraulic thrust or brake shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

(g) Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS: 2903 / BS: 3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook.

(h) Hoist rope shall be extra flexible, improved plough galvanized steel rope with well lubricated hemp core and having six strands of 36 wires per stand with minimum ultimate tensile strength of 1.6 X 106 kN/m2 of Right Hand Ordinary (RHO) lay construction. The ropes shall have a 6:1 safety factor on the specified safe working load, and shall conform to IS:2266. Rope drums shall be grooved and shall be either cast iron or cast steel of or welded steel conforming to IS:3177, BS:466 or relevant internationally approved standards.

(i) Gears shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, quality of steel, heat treatment, face, pitch of teeth and design shall conform to BS:436, IS:4460 and BS: 721 or relevant internationally approved standards.

(j) Name Plate showing the capacity, year of manufacture and rated capacity of hoist in figures not less than 150 mm height shall be placed on each side of the crane girder.

(k) The maximum deflection under full load shall not exceed 1/900 of the span (as per IS: 3177).

(l) All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant push button station, protective devices, operating devices, cables, conduits, etc. necessary for the safe and satisfactory operation of the crane shall be provided. (Power to the crane shall be provided by down shop

conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces.

Pendant type push button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lamps:

a. 'Start' and 'Stop'.
b. Long travel – 'Right' and 'Left'.
c. Cross travel – 'To' and 'Fro'.
d. Hook – 'Hoist' and 'Lower'.
e. Red indicating lamp for supply 'ON' indication.

(m) Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent overtravel for each of the following:

a. For 'UP' and 'Down' motions of the hook.
b. Long travel motion
c. Cross travel motion

(n) Crane structures, motor frames and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor unit sets shall be provided with two studs for earthing.

(o) The crane, and all slings, ropes, shackles and other lifting equipment supplied shall be tested by the manufacturer at his works. The tests shall be carried out at 125% of Safe Working Load, and Test Certificates shall be supplied.

(p) All motors shall be of the quick reversing type with electric mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the hook loaded. Facilities shall be provided for the accurate location of the hook by means of `inching' the cross travel and down shop travel motions.

(q) Sufficient slings, ropes, shackles, lifting beams, etc shall be supplied to handle all items of plant covered by the crane. They shall be labelled or marked with the Safe Working Load (SWL) and the purpose for which they are intended.

(r) The Contractor shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail-safe protection in the event of an interruption in the power supplies. All access ladders and platforms necessary to carry out maintenance and repairs shall be provided and installed by the Contractor.

(s) All electrical equipment shall be fully tropicalised.

(t) Site tests shall be carried out by the Contractor who shall supply the necessary materials for the test load. The test load shall be removed from site by the Contractor after successful tests have been carried out.

8.17 Jib cranes

(a) Fixed Jib Cranes shall be provided for each clarifier in the lowering/removal of equipments/parts to/from the clarifier floor and transferring the same outside the clarifier area. The Jib Crane capacity shall be 1.25 times the maximum weight to be handled in the clarifier or 1.5 Tonnes whichever is maximum.

(b) The lift and reach of the cranes shall be suitable for the clarifier offered. The crane shall be capable of being swivelled by 360°. Adjacent halves of clarifiers may be provided with common jib crane if feasible.

All materials used in the construction shall be corrosion resistant. Mild steel used shall be galvanised. Ropes, chains and pulleys shall be of stainless steel construction. Hardware shall be of SS 316. The Jib crane shall also be provided for handling submersible mixers in Pre-Anoxic Tank and Anaerobic Tank.

8.18 Grit Removing Equipment (Vortex Type)

A Vortex type grit removal system capable of removing 95 % of grit. (down to 105 micron partice size) with complete grit washing and handling components shall be provided.

Vortex type cyclonic grit rators shall be designed according to following requirements.

Specific Gravity of Grit: 2.60
Retention Time in Grit Chamber: 30 s

A grit storage hopper with a slope of 60° or more sloped to the bottom shall be provided with effective grit storage for the designed flow.

Grit removal equipment shall meet following standards;

MOC: Wall Thimble, Frame and slide: CI IS 210 FG 200

Sealing Face: SS ASTM A 743CF8FM
Stem : SS ASTM A 276 Type 316
Stem Nut: SS ASTM A 743 CF8M
Stem Coupling, Fastner & Anchors: SS ASTM A 276 Type 316
Lifting Mechanisum, pedestal Gear House Cover and Stem Guide: CI IS 210 FG 200
Lift Nut: Bronze IS318 LTB2 with necessary accessories

MOC of Wet Part: SS 304

Outlet of Grit Chamber for isolation spindle height shall be confirmed by bid drawing:

MOC: Wall Thimble, Frame and slide: CI IS 210 FG 200
Sealing Face: SS ASTM A 743CF8FM
Stem : SS ASTM A 276 Type 316
Stem Nut: SS ASTM A 743 CF8M
Stem Coupling, Fastner & Anchors: SS ASTM A 276 Type 316
Lifting Mechanisum, pedestal Gear House Cover and Stem Guide: CI IS 210 FG 200
Lift Nut: Bronze IS318 LTB2 with necessary accessories
MOC of Wet Part: SS 304

8.19 Fine Bubble tubular Membrane Diffusers

(a) Provide a retrievable arrangement that provides complete mixing and aeration of basin contents.

(b) Space diffusers evenly along each header.

(c) Furnish all components necessary to provide a complete mixing and aeration system. Work shall include but not necessarily be limited to the following:

- ✓ Flanged connections (SS 316) at the upstream side of each drop leg for connection to an isolation butterfly valve.
- ✓ Stainless steel Drop legs (SS 316).
- ✓ Slip joint connections to the air distribution header (SS 316).
- ✓ Stainless steel Air distribution headers (SS 316).
- ✓ Diffuser connectors (SS 316).
- ✓ Tubular diffuser assemblies with EPDM or silicone elastomer membranes with anti-microbial coating.
- ✓ Anchored Supports (SS 316) as necessary
- ✓ Gaskets.
- ✓ Header joints (SS 316).
- ✓ Bolts, nuts and washers (SS 316).

(d) Provide two tubular diffusers at each header connection. Mount to a reinforced tee located on the bottom centerline of the header. The reinforced Tee shall be adjustable to allow accurate alignment of the diffuser.

(e) The Diffusers should be able to withstand high blower air and water temperature.

8.19.1 Diffuser Assembly

- ✓ Provide orifice flow control to ensure orifice head loss is at least 2.5 times the head loss in the air header at all air flow rates in the diffuser's design operating range.

8.19.2 Air Header and Droplegs

(a) Header and drop legs shall be constructed of 316 stainless steel

1. Bottom elevation of the air distribution header shall be same throughout the tank.
2. Design connections between sections of the air distribution header to allow individual header sections to rotate independently of adjacent header sections.
3. Header dimensions shall conform to dimensional tolerances specified in ASTM A554-89 and ASTM A530-87.

(b) Furnish a drop leg from the air main connection at the top of the tank.

1. Provide a slip joint connection between the drop leg and distribution header.
2. Support the drop leg from the connection at the air header.

(c) Use factory welding only; field welding shall not be allowed.

1. Wire brush outside of each weld area.
2. Remove all discoloration and deposits left by welding by pickling.
3. Factory weld all diffuser connections. Stiffen both the diffuser connectors and the headers to withstand a moment of 56.5 N.m at the connector without permanent deformation.

(d) Passivate all SS 316 assemblies and parts after fabrication by immersion in a pickling solution of 6 percent nitric acid and 3 percent hydrofluoric acid at 60° C for a minimum of 15 minutes.

1. Neutralize by immersion in a tri-sodium phosphate rinse.
2. Submit certificate that this has been done.

8.19.3 Supports and Anchors

(a) Provide wall and floor mounting supports for all drop legs and air headers as necessary to anchor firmly on the wall and to the bottom of the tank and as specified herein.

(b) Anchor supports to concrete walls and floors using stainless steel expansion bolts sized and spaced as required for the loads encountered.

(c) Design supports to allow leveling the air header and diffuser assemblies to within specified tolerances.

(d) Provide expansion couplings in the drop legs and air headers as necessary to accommodate anticipated thermal expansion and contraction.

1. Submit expansion coupling design as well as computations for sizing.

8.19.4 Spare Parts

Provide spare parts in the quantities indicated.

Item	Quantity
Diffuser Assemblies	10%
Orifice Inserts	10%

8.19.5 Installation

(a) Install all components in accordance with the manufacturer's instructions and recommendations.

(b) Install all diffusers to within +/- 10 mm of a common horizontal plane.

8.19.6 Field testing

(a) All Fine bubble diffused aeration systems will be field tested.

(b) Testing will verify the installation as well as the diffuser's ability to deliver the specified air flow rates at the manufacturer's stated pressure loss. Testing will also verify the uniformity of mixing provided.

(c) Leveling tests:

1. Introduce clear water into each tank to the top of the diffuser elements.

2. Check the level of the diffusers to document that all element horizontal surfaces are within 10 mm of a common horizontal place and at the specified elevation.

8.19.7 Leakage and distribution of flow tests:

(a) After successful completion of the leveling tests, raise the water level to 50mm above the manifold.

(b) Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.

(c) Pressure test:
All of air supply pipe line shall be tested by pressure. Test pressure shall be at least 2 times higher than normal operation pressure.

(d) If client is unsatisfied any test result, repeat the test until the installation is essentially void of air leaks.

(e) Repair any leaks in the elements holders, elements, pipes or the like.

8.19.8 Disc Fine Bubble Aeration System

Design:
The Disc membrane diffuser shall be developed specifically for Releases 1~3mm fine bubble in the wastewater treatment plant. All materials have been selected for their ability to withstand the effects of the chemical, bio-chemical agents and 0~100°C used in wastewater tank. The diffuser can be placed in an evenly distributed grid system over the entire aeration tank bottom. Air can be easily through the air orifice and integrated non-return valve into the wastewater. The air orifice design to maintain the diffuser standard airflow input prevented the max. air enter to damage diffuser membrane. The membrane shall be secured onto the support dish with a constrict flex rim and retaining ring designed to increase the tension on the point of engagement as the diffuser air rate increases.

Construction:
The materials of construction for both support dish and membrane diaphragm are non-corrosive and UV resistant. The support dish shall be upward facing convex plastic (Glass filled reinforced Polypropylene) for working without any acid dosing requirements and integrated non-return valve designed for back-flow prevention while airflow is interrupted. The membrane diaphragm which covers the dish is made of high grade EPDM resistant to the usual sewage ingredients. The membrane shall be further fastened to the support dish with a U-type retaining ring without special tools for fastening or replacement the membrane.
Aeration system shall be retrievable grid, membrane disc fine bubble aeration system

The fine bubble aeration system will comprise:

Stainless steel (SS316) droplegs and Headers.

- SS316 manifolds and air distributors.
- SS316 diffuser holders and retainer rings.
- Stainless steel supports and anchors
- Bolts, nuts and gaskets for aeration system flange connections.
- Air distributor purge systems.
- Membrane disc diffusers with integral O-ring gaskets and subplates.

The following design features will be incorporated in the fine bubble aeration system:

- Fabricated manifold with fixed threaded union joints for connection to the air distributors.
- Manifold sections connected with fixed threaded union or flanged joints to prevent rotation or blow apart.
- Manifold, distributor connections and supports designed to resist thrust generated by expansion/contraction of the air distributors over a temperature range of 70°C
- Air distributors perpendicular to the air manifold
- Fabricated distributors with single diffuser holders solvent welded to the crown of the air distributor for complete air seal and strength.
- Distributors and holders designed to resist a dead load of 90kg applied vertically to the outer edge of the diffuser holder.
- Air distributor sections joined with positive locking fixed threaded union or flange type joints for all submerged header joints to prevent blow apart and rotation. Bell and spigot, slip on or expansion type joints are not acceptable for submerged joints.
- Threaded union joints designed with spigot section connected to one end of the distribution header, a threaded socket section connected to the mating distribution header, an “O” ring gasket and a threaded screw on retainer ring. Solvent welding shall be done in the factory.
- Air distributor support spacing at a maximum of 2400mm.
- All supports designed to allow for thermal expansion and contraction forces over a temperature range of 70°C and to minimize stress build up in the piping system
- Supports designed to be adjustable without removing the air distributor from the support.
- Diffuser assembly comprising: diffuser membrane with integral "O" ring, sub-plate, holder, retaining ring and air flow control orifice.
- Integral check valve incorporated into the membrane diffuser assembly
- PVC support plate incorporated to form an air plenum under the diffuser and support for the membrane when the air is off
- Retainer ring threads designed with minimum cross section of 3mm and to allow for one complete turn to engage threads.
- A liquid purge system to drain the entire submerged aeration piping system for each aeration grid including airlift purge eductor line and manual control valve.
- Circular membrane diffuser discs with integral O-ring will be manufactured of EPDM synthetic rubber compound with precision die formed slits. Thermoplastic materials (i.e. plasticized PVC or polyurethane) are not acceptable.
- Carbon black will be added to the EPDM material for resistance to ultraviolet light.

- The maximum tensile stress on the diffuser will be limited to 10 psi (69 kPa) when operating at 2.4 SCFM/sq. ft. (43.9 Sm 3 /h per m 2) of material. Proportionately thicker material is to be furnished for larger diameter disc diffusers to limit the maximum tensile stress and to resist stretching.

Supports and anchors, spare parts, installation method, field testing, leakage and flow distribution tests shall be same as per above clause nos. 8.18.3 to 8.18.7.

8.19.9 Rotary Air Blowers

(a) Compressor blowers shall be of the rotary tri or twin lobe positive displacement type, each provided with inlet filter and silencer, pressure reducing valve, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend or silencer in the delivery branch. Bearing housings and gear boxes shall be separated from the blower housings by air spaces. The units shall be complete with a self contained oil cooling system for the bearings. The blowers shall be housed in a separate sound proof room to reduce the noise level or inside acoustic enclosure. The noise level shall not exceed 90 dBA at 1 meter from the Blower.

(b) The bearings shall be generously designed to give long operational life. Bearings at the drive end may be oil or grease lubricated. The gears and bearings at the non-drive end shall be oil lubricated. Bearings shall be provided with oil throwers to prevent leakage of oil. The blower shall be arranged for horizontal inlet and vertical outlet, delivery velocity not exceeding 20 m/s and each blower shall be provided with following components but not limited to:

(1) Common base frame for Blower & Motor.
(2) Inlet silencer and filter.
(3) Discharge Silencer & non-return valve in delivery branch.
(4) Motorised Butterfly valves in both inlet and delivery branches with metal to metal sealing.
(5) Pressure relief valve or excess pressure safety device.
(6) Bellows SS 316 type couplings on inlet and delivery branches.
(7) Acoustics Enclosure.
(8) V-Belt drive arrangement with Belt Guard.
(9) Isolating valves, Pressure reducing valves & Pressure gauges
(10) Air Flow meters, Temperature gauges.
(11) Water trap.

(c) The interconnecting pipe work shall be flanged to BS EN 1092-1/BS: 4504. A drain cock shall be provided at the lowest point in the each delivery pipe work along with reflux valve. Individual stop valves and safety valves shall be provided for each unit.

(d) Blowers shall be driven by squirrel cage motors through a matched V-belt drive. Motors shall be mounted on slide rails mounted on a common bed plate, to facilitate the tensioning of the belts. Blowers shall not run above 1000 rpm.

(e) Each delivery branch shall include a drain at the lowest part and a reflux valve.
Each blower shall contain one inlet air pressure, one discharge air pressure, and one discharge air temperature gauge. The pressure gauges shall be calibrated in kPa absolute and be of the compound type. The gauges shall have circular dials, minimum 100 mm diameter with black figures on white background. Pressure gauges shall be furnished with pulsation damper. Temperature gauges shall be manufactured with standard temperature bulb.

(f) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same.This cooling arrangement is mandatory with all types of Blowers.

Material of Construction

a	Blower Housing	Cast Iron IS 210 FG Gr.260
b	Lobes	Cast Iron IS 210 FG Gr.260
c	Shaft	SS410
d	Base plate	MS Epoxy
e	Inlet filter, silencer casing	Galvanized steel
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow-off silencer and motor cooling silencer	Galvanized steel
i	All connecting accessories and anchor bolts	AISI 316

8.19.10 Acoustical Enclosure

(a) Provide a factory assembled acoustical enclosure around the entire blower. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all blower parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel.

(b) Provide clear, transparent Lexan or plastic windows to visually observe gauges and lever arms of the variable guide vanes and diffusers.

(c) Mount an auxiliary exhaust fan and thermostat on the acoustical enclosure to provide air circulation after blower shutdown or when the temperature inside the enclosure exceeds 40^{o}C.

(d) The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

8.19.11 Centrifugal single stage blower

Blower Structure

a) The blower shall be of single-stage centrifugal, and shall be designed integral type. The flow rate should be adjustable by controlling the rotation speed with frequency converter or inlet vane or discharge guide vane according to the inlet temperature and differential pressure to ensure the optimal power consumption. Regulation should be possible in the range of 10050% of the specified design flows at all project design temperatures and at design pressures.
b) The regulation should be fully automated and contain a program for continuous optimization of blower efficiency with respect to changes in inlet temperature, differential pressure and required flow.
c) The pressure grade of the blower casing shall be minimum PN10.The casing shall be cast and bolted together and allow the impeller to be removed with the casing in situ.
d) The impeller shall be open radial flow type (with backward leaning) and made of aluminium alloy, all surface of the vanes should be finish machining.
e) High frequency, variable rotation speed and air-cooling motor should be adopted. The impeller and cooling fan should be directly connected with the motor shaft.
f) The motor shall be equipped with magnetic bearings (If required), which should have the characteristic of magnetic suspension and continuous variable rotation speed. The motor should be installed at a frame with flexible fastening devices.
g) Two radial magnetic bearings and one axial magnetic bearing shall be orientated accurately via the active-bearing controller controlling the rotor. The active bearing controller shall be powered by one DC and one 3 phase AC input. The service life of all bearings should be more than 100000 hours.
h) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of fine bubble diffusers and satisfactory performance of the same. This cooling arrangement is mandatory with all types of Blowers.

i) The local control cabinet should be equipped with display screen and keypad unit. The running state of the blower should be able to monitor at real time. The displayed data at least include the following:
    - Actual flow (%)
    - Running time (hour)
    - Running time (day)
    - MWh counter
    - Differential pressure
    - Reference flow (%)
    - Model of the blower
    - Power frequency of the motor (Hz)
    - Current (A)

- Transition temperature
- Motor temperature

j) When operating, if the control system finds fault, the blower will give an alarm automatically or stop and the fault code will be displayed at the control cabinet. All signals can be transferred to the control centre of the plant.

k) The blower should have the following protection functions (but not limited to):

- Over voltage of the main power supply
- Under voltage of the main power supply
- I-phase fault
- Over voltage/Under voltage of the auxiliary power supply
- Inlet and outlet air pipe blocking
- Air temperature is higher than the specified limited temperature
- Cooling air temperature is high than the specified limited temperature

Accessories

a) Inlet filter and silencer :
Each blower shall be provided with an inlet filter/silencer mounted directly on the inlet of the Blower via a flexible connection. Such mounting is for the purpose of reducing pressure drop across the inlet appurtenances and of minimizing noise from pipes. Filter/silencer housing shall consist of galvanized steel plate and acoustical sound-deadening material on the inside. Filters shall be removable through easily accessible doors and have very high removal efficiency and shall be sized for maximum face of velocity of 2m/sec at peak air flow.

b) Discharge Flex Connector :
Each blower shall be provided with discharge expansion Bellows joint of SS316. The expansion joint shall alleviate stress caused by thermal expansion and contraction in the piping system. The expansion joints shall be capable of withstanding the pressure under all operating conditions and shall be rated for temperatures up to 160°C.

c) Discharge Cone Diffuser Silencer :
Each blower shall be supplied with a combined discharge cone diffuser-silencer to increase the discharge from the blower outlet to the discharge pipe, thus reducing the air velocity to max. 20 m/sec. The length of the discharge cone shall be aerodynamically designed in order to recover dynamic pressure head and minimize discharge turbulence. The discharge cone shall be constructed of galvanized steel plate and acoustical sound-deadening material on the inside, with flanges, and be equipped with a stud for a possible measuring device.

d) Blow-off (Bypass) Valve :
Each blower shall be provided with a blow-off valve to allow unloaded start-up and unloaded stop. The valve operator shall be motorized, equipped with open/closed limit switches, and shall be

suitable for air service at 200°C operating temperature. Controls for the valve shall be mounted in each local blower control cabinet with indicating light.

e) Blow-off silencer :
Blow-off silencer shall be provided for each blower and mounted on the discharge by-pass line. The blow-off valve silencer shall be constructed of galvanized steel and contain sound absorption material encased in an outer shell. The silencer shall have one sleeve inlet connection for mounting onto the end of the bypass line.

f) Discharge check valve (Back-flow Barrier) :
Each blower shall be provided with one discharge check valve flange ends located in the discharge side pipe work, spring loaded butterfly design for mounting between flanges according BS EN 1092-1/BS: 4504. The pressure losses of the fully open valve must not exceed 1.0 kPa. The valves shall be rated for temperatures up to 160°C.

g) Noise Protection Cover:
The blower and motor should be covered with one Acoustic cover, which should be equipped with electric cooling ventilator.

h) Base plate and anchor bolts:
Each blower unit shall be furnished with a frame of adequate size to support the blower, motor, magnetic bearing controller frequency converter, control cabinet and other accessories. The base plate shall be constructed of fabricated steel, provided with lifting lugs and of sufficient rigidity to permit lifting by a fork-lift, with all equipment mounted, without distortion or other damage to the base plate or to components parts of the machinery.

Material of Construction

a	Blower Housing	Ductile Iron
b	Impeller	Aluminium alloy
c	Shaft	SS410
d	Base plate	Profiled steel
e	Inlet filter, silencer casing	Galvanized steel
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow-off silencer and motor cooling silencer	Galvanized steel
i	Inlet cone extension	Galvanized steel
j	All connecting accessories and anchor bolts	AISI 316

Control

The control system of the blower should be well connected with the control system of the whole plant. All the real time monitor and protection function shall connect with the control software; the remote control shall be carried out with 4-20 mA or network.

Local control panel and control cabinet shall be combined, that include display screen and keypad, main switch and lock stop push button. The blower operation shall be controlled by the main running switch and keypad.

Performance Guarantee:

The Performance of the compressor shall be guaranteed according to the requested project design values subject allowed tolerances on Flow & Pressure: +/- 0%, and Power: 2%.

Compressor or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

8.19.12 Submersible Mixer

(a) The submersible mixer shall be installed in the specified plant areas, and they shall be capable of providing a velocity gradient in the range of 500 to 1000 mm/sec.

(b) The mixer shall have a self-cleaning propeller optimized for effective mixing and vibration-free running, and required power shall be at least 10Watt/m^3 of tank volume.

(c) The mixer shall be driven by a submersible high efficiency 3 phase motors IP68 Class F. Motor shaft and rotor shall be dynamically balanced.

(d) Bearings shall be lubricated-for-life with a calculated life of more than 100,000 operating hours.

(e) The mixers shall have the flexibility to be located at different depths and thereby avoiding dead zones.

(f) The mixer shall be provided with the following :

(1) Lifting frame with a winch which can be dismantled, fee standing with adjustable boom length.
(2) Mounting socket for free standing hoist suitable for wall mounting.
(3) Guide for floor fixing components and support brackets for wall mounting.
(4) Stainless steel (SS316) rope for raising and lowering the mixer.

(5) Rope block for holding the stainless steel 316 rope where the lighting frame is used in different locations.

(6) Support rope for reliable support and guidance of power supply cable.

(7) Support clamps and hooks to support the power supply cable in such a manner that it is not under strain.

(g) The propeller, and motor housing, guide pipe, support brackets and all fasteners shall all be of SS 316. The propeller shaft shall be of SS 431.The winch shall be of Stainless Steel construction.

8.20 Conveyor System

(a) For the disposal of sludge a common motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects which will cause shock loads.

(b) The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of 20 deg. Trough type complete with drive assembly structures, idlers, pulleys and belt cleaners. Idlers and pulley shall be provided with anti-friction bearings.

(c) The belt material shall be two ply nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length centre tube journalled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide prestressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment or ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying run and 2400 mm on return run.

(d) The head and tail pulleys shall be manufactured from welded steel/any alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. The tail pulley shall incorporate a screw rake for adjusting belt tension. Head and tail pulleys shall be adequately guarded.

(e) Shafting for pulleys shall be of heat treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided with roller bearing pillow blocks.

(f) The belt conveyor shall be driven by a squirrel cage, TEFC motor. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have back stops to prevent backward movement of the belt.

(g) The conveyor shall be supported on appropriate channel sections with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a "dog box" type canopy.

(h) An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fiberglass/fibre reinforced plastic/PVC.

(i) Sludge cake discharge Hoppers shall be provided to transfer the sludge cake from the Centrifuge to the troughed belt conveyor and from the conveyor discharge to skip. The latter chute shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chutes shall be designed to minimize the accumulation of rags and stringy materials.

The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. belt sway switches shall be provided on conveyor.

8.21 Progressing –Cavity Pumps

(a) Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pump to give a uniform positive displacement.

(b) Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion, a corrosion resistant shroud shall be fitted to prevent fiber build-up on the shaft. Enlarged inspection access holes shall be fitted to the suction chambers of all pumps for periodic removal of accumulated debris. The shaft bearing shall be positively isolated from the fluid being pumped.

(c) The rotor material shall be selected for corrosion and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome or other approved coatings shall be not less than 250 micron thickness and shall be diffused in to the base material. The rotor shall

Generally be single-stage and shall incorporate not less than 3600 of twist, but for high-head applications, it may be necessary to use more than a single-stage. The stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped. Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable-speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available speed range.

(d) Pumps shall normally be driven by a fixed-speed electric motor through reduction gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in-line on a common base plate. Alternatively, the drive motor may be top-mounted above the pump to minimize floor area, and shall be connected by external V-belts and pulleys. V-belt drives shall have full guards of the type that allow the belts observed without removal of the guard. Facilities shall be provided for ready adjustment of belt tension.

(e) Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance and routine inspections.

(f) All motor enclosures shall be provided with ingress protection to IP55. Motor anti-condensation heaters shall be provided and shall be suitable for use on a 220V single-phase, 50Hz supply. All bearing shall have a B10 design life of not less than 40,000 running hours and shall be designed for loading 20% in excess of calculated maximum loading.

(g) Pumps shall be fitted with individual dry-running protection to initiate pump trip. Dry-running protection by "under-current" monitoring or "pipeline-intrusive" device shall not be used.

Material of Construction

S. No.	Component	Material
1	Pump Housing	CI IS210 Grade220 or 260
2	Rotor & Coupling/Connecting Rod	SS AISI 316(HCP) 250 Microns
3	Shaft	SS AISI 410(HCP) 250 Microns
4	Stator	Nitrite black
5	Type of drive	V belt & Pulleys
6	Base plate	MS fabricated
7	Mechanical seals	oil-lubricated with tungsten carbide or silicon-carbide faces

Pumps models (handling water) shall be selected such that when handling sludge it meets the required duties of the viscous liquid. Pumps shall be selected which gives the required duties close to best efficiency point.

8.22 Occupational Health and safety Management

Occupational Health and Safety Management

In order to prevent the industrial accident, for example a fall accident, physical damage, drowning, toxic chemicals and Gas, dropping, flammable oil and Bio-Gas, which may be occurred during O/M and Construction stage, the contractor shall provide a suitable for safety measures need to be implemented.

Especially the sludge digestive facilities need to be enhancement in the incidental facilities, and monitoring apparatus for carrying out stable generating of the digestive Bio-gas.

Since bio gas has a highly inflammable, the constructor shall provide a suitable safeguard and its monitoring devices for preventing an outbreak of an explosion accident and a fire.

Moreover, preparation of early firefighting devices is required for emergency action.

In the sludge treatment machine building shall be provided a ventilation system and a gas disclosure detector in order to secure a worker's labor and safety.

The inside of the sludge handling facilities shall be installed a sign of prohibition of smoking and fire and safety education to the personnel periodically.

8.20 Chlorination System

Chlorine solution diffusers shall be supplied and installed at the dosing point.

Treated sewage shall be dosed with chlorine gas at concentrations not more than 10 mg/l. Effluent from the chlorine contact tank shall not have more than 1 mg/l of residual chlorine.

8.20.1 Chlorinators

(a) Vacuum type chlorinators shall be supplied with one duty and one standby unit.

(b) Chlorinators shall be free-standing, floor-mounted, and shall have a turn down ratio of 10: 1 over the full range of works operation.

(c) Each chlorinator shall be equipped with a motorized plug positioned to be actuated by a sewage flow at the works outlet.

(d) The dosing rate shall be manually set and each chlorinator shall be equipped with a 0 to 10 mg/l scale and a manual dose setter over the complete range.

(e) Mal-operation of the duty chlorination system shall be indicated in the chlorination room and the central MMI. The change to the standby system shall be carried out automatically in the event of a duty chlorinator failure.

8.20.2 A: Motive water pumps and Injector

(a) Motive water pumps (1 working + 1 standby) shall be installed.

(b) The pumps shall draw their supply from bore well/plant water supply.

(c) The pumps shall be installed outside the chlorination room and shall be made from material resistant to corrosion by chlorine.

(d) Two injectors shall be provided, each serving a duty / standby pair of chlorinators. The injectors shall be located near point of dosing i.e. upstream of Chlorine contact tank.

8.20.3 B: Inline vacuum induction type chlorine injectors

(a) Inline vacuum induction type injector shall be designed for chemical induction and mixing for closed conduits and consist of induction unit, motor, lift rail, chemical hose assembly, stainless steel packing gland assembly and ball check valve.

(b) All wetted materials shall be constructed of Grade 2 Titanium (unalloyed). The motor shall be chemical duty type.

8.20.4 Chlorine

Chlorine shall be supplied as liquid from nominal 1 tonne chlorine tonner.

8.20.5 The Tonner Room

(a) Storage shall be provided for chlorine tonners sufficient for at least one month‟s usage at normal rates of application.

(b) The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.

(c) Tonners on line, tonners on standby and full and empty tonners, shall be stored separately in the tonner room.

(d) Four sets of tonner rollers shall be provided. Tonners not in use shall be stored on concrete cradles.

(e) A 2-tonne overhead single girder electric travelling crane shall be provided in the chlorine tonner room for the following functions:

(1) Offloading (and reloading) of tonner from trucks;
(2) Handling of tonners within the storage area.

(f) The system shall serve the tonner store width over the entire length including the loading/ unloading area.

(g) The hoist and traverse speeds shall be as follows ;

(1)	Long traverse speed	:	5m/min
(2)	Cross traverse speed	:	not more than 5m/min
(3)	Slow lifting speed	:	1m/min
(4)	High lifting speed	:	5m/min

(h) The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks.

(i) Operation of crane system shall be from the floor level using independent push button pendant controls operating at a 230 volt 50 Hz AC supply.

(j) Two lifting beams shall be provided (a duty and a spare) and a one tonner weigher to be suspended from the crane hoist.

(k) When the pressure in the duty chlorine tonner falls to less than 1 kg/cm^2 the automatic changeover device shall operate to isolate the empty tonner and to bring the full standby tonner on line.

(l) A pit and alkali absorption system shall be provided to contain and neutralise chlorine in the event of a leak. The system shall comprise a pit located in the tonner storage room,suitable pump in SS CF8M material and accessible by the overhead crane system. The pit shall be surrounded with removable guard railing. The pit shall be kept full with a neutralising solution of lime. The pit shall be capable of holding side by side two chlorine tonners. A provision shall be made to drain the pit.

(m) In addition to the above Automatic chlorine leak absorption system (Gas Scrubber with NaOH dosing) shall be provided adjacent to the Tonner room. The process shall be designed to contain and neutralize chlorine gas vapours in response to gas leak or catastrophic cylinder failure. The system should be able to absorb 99.99% of the chlorine gas entering the scrubber.

When a leak occurs, the pump and fan shall start automatically. The fan shall provide sufficient vacuum to contain the chlorine gas and deliver it to the scrubber. The pump shall circulate the concentrated caustic solution over the scrubber packing to absorb all the chlorine gas.

(n) Special consideration shall be given to any floor drainage system in the tonner building; adequate traps shall be provided to ensure that chlorine gas cannot escape. All leader tubes carrying cables or pipes out of the building shall be sealed at either end to prevent any chlorine gas leaking out.

8.20.6 Chlorination Room

(a) The chlorination room shall be constructed adjacent to the tonner room but with no interconnecting door or other form of access.

(b) Gas lines from the tonner room into the chlorination room shall run in ducts to be sealed after installation and prior to commissioning.

8.20.7 Chlorine Leak Detectors

Not less than three chlorine gas leak detectors shall be provided each, with a single detector cell. At least two sensors shall be located in the chlorine tonner storage room and at least one sensor in the chlorination room. The chlorine leak detectors in the tonner room shall be mounted at each end of the tonner room.

a) The chlorine leak detectors shall have two adjustable alarm levels sensitive to chlorine concentrations above 1 mg/m3. The range of adjustment of alarm levels shall facilitate selection of the following alarms:

(1) low level 2 mg/m^3

(2) high level 4 mg/m^3

The low level alarm shall:

(1) Initiate a local audible and visual alarm;
(2) Start the ventilation fans in the tonner and chlorination rooms;
(3) Raise an alarm at the local control panel and at the central MMI.

The high level alarm shall:

(1) Initiate local audible and visual alarm;
(2) Initiate audible and visual alarms outside the buildings (the alarm shall be sufficiently loud to be heard in all buildings at the STP);
(3) Raise an alarm at the local control panel and at the central MMI;
(4) Shut down the chlorination systems;
(5) Stop the tonner room and chlorination room exhaust fans.

(b) The chlorine detectors shall have self-checking circuitry and detector failure alarms shall be provided at the local control panel and central MMI.

(c) Detector failure alarms shall not be combined with the leak alarms.

(d) Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in Kannada and English.

8.20.8 Ventilation System

(a) Each area where chlorine is stored or used as gas or liquid shall be provided with a forced ventilation system.

(b) Air intakes shall be sized to allow uniform ventilation and positioned to prevent possible recirculation.

(c) Exhaust air shall be ducted from low level and discharged at high level.

(d) An air change rate of four per hour under normal condition and a minimum of twenty changes of air per hour under shall be used in the event that a chlorine leak is detected.

(e) Exhaust fans shall be heavy duty industrial pattern manufactured from chlorine resistant materials.

(f) Ductwork (Minimum 400mm ID) shall be manufactured from Aluminum sheets/PP(3mm)+FRP(5mm)in circular or rectangular sections.

(g) Ducts shall be designed in accordance with relevant Indian standard specifications.

(h) Fan controls shall be linked to the gas leak detection system.

(i) Hardwired fan controls shall be provided and shall be manually controlled. An override shall be provided to operate the fans in the event of a chlorine leak alarm.

(j) Fan controls shall be grouped in an enclosure outside the ventilated area and shall include the following:

(1) fan off/on;
(2) fan running/failed indication lights;
(3) low and high gas leakage indication alarm light.

8.20.9 Chlorine Residual Monitors

(a) Chlorine residual monitors shall be provided at the plant outlet.

(b) The monitor installation shall be located in a covered location easily accessible for viewing and maintenance and shall be provided complete with sample pumps as necessary to ensure the continuity of the sample.

(c) The sampling pipe work complete with isolation valves etc. shall be designed to ensure the sample reaches the monitor in a time not greater than 1 minute. The monitor drainage pipe work shall permit the visual checking of the presence of flow and shall discharge to the foul drain. Sample sewage not passed through the monitor shall be returned to the process.

(d) The residual signals shall be displayed at the local control panel.

(e) High and low chlorine residual levels shall raise alarms at the local control panel.

8.20.10 Safety Equipment

(a) Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.

(b) The equipment shall include:

(1) Two sets of approved self-contained breathing apparatus, each comprising an air set, carrying harness, face mask and valves and ancillary equipment. Each set shall be provided with three 1200 litre capacity, 140 mm diameter, air tonners;

(2) Two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline. One air trolley, comprising wheeled frame with two air

tonners, control manifold, airline hose and hose winding drum. Two spare tonners suitable for changeover shall be provided ;

(3) One portable electric motor driven air compressor for recharging air tonners, complete with quick-release air hose couplings;

(4) Two `instant action' resuscitators.;

(5) Four sets of safety clothing in various sizes, each comprising PVC overalls, wellington boots with steel toe caps, goggles, gloves and safety helmets.

(c) Each set of safety equipment shall be mounted in a glass-fronted, non-locking PVC coated steel cabinet in approved locations on the outside of the building.

(d) Two emergency showers shall be provided and shall be installed outside on either side of the tonner room.

(e) Each shower shall be operated automatically by a quick acting hand or foot valve.

(f) Four eyebaths shall be supplied. Two eyebaths shall be adjacent to each of the showers.

(g) Water for the showers, etc, shall be drawn from the service water supply.

(h) A telephone will be provided close by outside the building for emergencies.

8.20.11 Chlorination Power and Control

(a) A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for :

(1) Display status and values associated with the chlorination systems;
(2) Duty pump selection;
(3) Annunciate alarms associated with the chlorination systems;
(4) Operator adjustment of process set points.

(b) The chlorination systems shall operate using a fixed manually set dose rate. The quantity of chlorine dosed will therefore be adjusted in direct proportion to the process flow at the dosing point.

(c) The chlorine residual monitors to be provided shall be used for monitoring and alarm purposes only.

8.21 Plant Drainage Pump set

(a) The total head capacity curve shall be continuously rising towards the shutoff with the highest at shut off.

(b) The pump shall run without undue noise and vibration.

(c) The power rating of the pump motor shall not be less than the power required from zero discharge to zero head.

(d) Pump shall be submersible type with double mechanical seals. Motor shall be of IP 68 protection.

(e) It shall be suitable for handling turbid water. Pump and motor shall have common shaft.

(f) Delivery pipe of drainage pump sets shall be of size 40 NB and as per IS 1239, heavy class. Required length of pipes and fittings shall be provided. Pumping main shall be common for two pumps.

(g) Level switch to start and stop the pump automatically shall be supplied with the pump. A level indicator shall also be provided.

(h) The capacity, total head and range of operating head of drainage pump set shall be as specified in particular mechanical requirements.

(i) The material of construction of pumps shall be as follows :

S. No.	Component	Material
(i)	Impeller	Stainless Steel :ASTM743CF8M
(ii)	Casing	Cast Iron : IS 210 Gr. FG 200
(iii)	Shaft	Stainless Steel: BS:970 GR 410

8.22 Fire Extinguishers

(a) Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is more stringent.

(b) All the extinguishers shall be of TAC approved.

8.23 Propeller Exhaust Fan

(a) The fan should comply with IS 2312.

(b) The blades shall be of mild steel and properly balanced so as to avoid noise and vibration.

(c) The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.

(d) Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum temperature attained in the adjacent component parts.

(e) The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G.

8.24 Forced Fresh Air Circulation System

Fresh air circulation system is to be provided for the Raw sewage pump house and Blower room for circulation of fresh air to limit increase in temperature and also avoid stale air presence. The complete system along with all associated required air supply fans, exhaust fans, ducts, grills, galvanized bird screens, hoods and all necessary accessories shall be provided. Suitable arrangements to prevent ingress of rain water into building shall also be provided. The system shall be designed with required air changes and the contractor shall provide detailed calculations to determine the air capacity, static pressure etc. and relevant technical details for the approval of Engineer.

All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending of fabrication of ducts.

The ducts shall be fabricated from galvanized plain steel sheets conforming to IS: 277-2003. All duct work, sheet metal thickness and fabrication, unless otherwise directed, shall strictly meet requirements as described in IS: 655.

All joints shall be tight and shall be made in the direction of air flow. The ducts shall be reinforced where necessary and must be secured in place so as to avoid vibrations of the duct and its supports.

Volume control dampers shall be of an approved type, lever operated and complete with locking devices which will permit the dampers to be adjusted and locked in any position.

Exhaust fans of appropriate rating shall be provided for pumping stations. The contractor shall submit the fan selection details for approval.

For axial flow fans / propeller fans, speed limitation shall be as follows:

For impeller diameter of up-to 450 mm – maximum speed shall be 1500 rpm.

For impeller diameter above 450 mm – maximum speed shall be 1000 rpm.

Suitable designed guards shall be fitted to the inlet and the outlet sides to prevent accidental contacts. No inflammable material shall be used in the construction of fans.

Drive motors shall be rated at least 15% higher than the power requirement at duty point or 10% higher than the maximum power requirements at the selected speed, whichever is higher. Motor shall be conforming to TEFC, IP 54 protection.

8.25 Air-conditioning Equipment

The air conditioning units shall be of split type, with the outdoor condensing unit mounted on the terrace of the room or grouted on external side of the wall with suitable brackets.

8.26 Valves

(a) Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges. Flanges shall conform to ISO 7005, IS 6392, BS EN 1092-1/ BS 4504.

(b) Valves shall be double flanged type and the faces shall be parallel to each other. The flange face should be at right angles to the valve centre line. Back side of valve flanges shall be machined or spot faced for proper seating of the head and nut.

(c) Valves buried or installed in underground chamber, where access to a hand wheel would be impractical, shall be operated by means of extension spindle and/or keys. Wherever extension spindle is provided, the valve shall also be provided with suitable headstock.

(d) Valve of diameter 450 mm and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning and servicing.

(e) Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.

(f) The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel.

(g) Valves shall be free from sharp projections which are likely to catch and hold stringy material.

(h) All the valve shall be of 10 bar rating.

(i) All the valves on the suction and delivery side of the Intermediate and Terminal sewage pumping station shall be of Motorised Knife gate type.

(j) All valves in the plant shall be provided with dismantling joint/Flexible joint/SS bellows for ease dismantling.

(k) All the valves on the suction and delivery side of the Primary Sludge, RAS, Thickened Sludge, Centrifuge feed, Digester sludge and all sewage & sludge handling pumping system and for all sludge application in the plant shall be of Motorised Knife gate type.

(l) All the valves shall be provided with Bypass valve arrangement 10% of main valve size.

(m) 2 sets of ladders shall be provided in the raw sewage pumping station to facilitate access of valves.

(n) Telescopic valves shall be provided in sludge storage tanks for sludge withdrawal purpose.

(o) For all gas service and process air application the valve shall be Butterfly valves in Resilient seated (gas service) and Metal-Metal seated CF8M (for process Air service).

8.26.1 Electric Actuator

(a) All local controls shall be protected by a lockable cover.

(b) Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The gearbox shall be oil or grease filled, and capable of installation in any position. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.

(c) The valve actuator shall be capable of producing not less than $1^1/_2$ times the required valve torque and shall be suitable for at least 15 minutes continuous operation.

(d) The actuator starters shall be integrally housed with the actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.

(e) The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication.

(f) Each starter shall be equipped as follows :

(1) 2 No. Three phase magnetically operated line contactors with no-volt release and electrical and mechanical interlock.

(2) 1 No. Three phase thermal cut-out device.

(3) 1 No. Control circuit transformer fully protected by fuses on primary and secondary circuits.

(4) 1 No. Set of "Open", "Close" and "Stop" buttons.

(5) 1 No. Local- Off-Remote switches with padlocking facilities.

(6) 1 No. Set of torque and limit switches for "Open" and "Close" positions.

(7) 3 No. Sets of auxiliary limit switches in each direction.

(8) Valve position Analog Transmitter (i.e Actuator accept To Read Analog signal from Actuator to PLC and also To Write Analog Signal from PLC to Actuator) & mechanical indicator and handwheel for manual operation.

(9) Reduction gear unit

(10) Trip signals of Thermoswitch, Torque Switch and Thermal Overload Relay shall be provided for Indication and also integrated to PLC.

8.26.2 Butterfly Valve

Butterfly valves shall be of double eccentric and resilient seated type generally as per BS EN 593 and IS 13095.

Butterfly valves shall be suitable for bi-directional pressure testing. The valves shall be of double flanged long type.

The valves shall be electrically/pneumatically/manual operated to suit the process requirement mentioned elsewhere in this tender document. The valve shall be free from induced vibrations. Valve shall be suitable for mounting in any position.

The valve seat shall be of metal to metal seated design. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

The shaft shall be stainless steel with Bronze or equivalent seal with self-lubricating bearings. Disc pins shall be stainless steel. Rings shall be bi-directional self-adjusting suitable for pressure or vacuum service. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs.

All valve spindles and hand wheels shall be positioned to give good access for operational personnel. Valve of diameter 450 mm and above shall be provided with enclosed gear arrangement for ease of operation. The gear box shall be of worm and worm wheel design type, totally enclosed, grease filled and weather proof. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head of 1.15 times the specified rating. Valve and gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N. All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

Material of construction of valves shall comply with following requirement:

Item	PN 10Valves
Body	Ductile Iron to BS 2789 Grade 420/12
Disc	Ductile Iron to BS 2789 Grade 420/12
Shaft	Stainless Steel BS 970 Grade 431 S 29
Body Seat	ASTM A 240 CF8M
Disc seat	ASTM A 240 CF8M
Shaft Bearing	Bronze backed with PTFE
Internal Fasteners	Stainless steel AISI 316
Nuts, bolts & washers for pipe flanges	High tensile steel hot dip galvanized

The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation.

Valves shall be capable of closing against the maximum flow that can occur in system. The shaft shall be designed to withstand the maximum torque that will be imposed by the operator. It shall be secured to the discs by tapered stainless steel cotter pins.

Valves shall be provided with position indicator to show the position of the disc, mounted on the driven shaft end.

Rigid adjustable stop mechanism shall be provided within the gear box or elsewhere on the valve to prevent movement of the disc beyond the fully open or closed position (i.e. set points).

8.26.3 Sluice Valves

(a) Sluice valve shall generally confirm to IS 14846.

(b) Sluice valves shall be of non-rising spindle type. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage.

(c) Valves of 400mm and above shall be provided with thrust bearing arrangement for ease of operation.

(d) Valves of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.

(e) All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.

(f) All the hand wheels shall be arranged to turn in a clockwise direction to close the valve. The direction of rotation for opening and closing of the valve shall be indicated on the hand wheels.

(g) The material of construction of valve shall be as follows :

S. No.	Component	Material
(i)	Body	Ductile iron to BS 2789 Grade 420/12
(ii)	Doors	Ductile iron to BS 2789 Grade 420/12 with EPDM rubber encapsulated
(iii)	Spindle	Stainless Steel: BS:970 Gr 431
(iv)	Bush	Bronze : IS:318 Gr LTB2
(v)	Internal Fasteners	SS 316

8.26.4 Knife Gate Valves

Design & Construction Details:

The Knife gate valves shall be manufactured generally as per the latest AWWA C520-10 standards. The valve should be bonneted up to 300 mm size and bonnet less for higher sizes.

Other constructional features and details of components of the required valves are to be as under:

The valve body should be of ductile iron construction as specified. The valve should be provided with gate made of stainless steel of grade as specified and the gate should have beveled knife edge at the bottom to cut through and easily enter in the solids settled in the bottom and ensure positive shut-off / closure in sewage environment.

The Valve should be designed for sealing in uni-directional flow application.

The valve should be provided with replaceable type flexible sealing arrangement to offer drop tight shut off. The seals should be made of EPDM rubber and should be held in place by an easily removable type seal retainer ring. The seals should be mechanically retained in place in a machined groove on the face of seal retainer ring. The sealing system should be field replaceable at site.

The valve housing should have integral as cast tapered lugs provided for pushing the gate towards the flexible rubber seal only at the verge of closure with a view to avoid seal wear and achieve drop tight shut off. The surface of the gate coming in contact with the seal should be polished & buffed.

The bonneted valves shall have glandless design to avoid repeated tightening / replacement of gland packing. The stuffing "O" ring seal should be pressurized by thrust washer from both the sides and should be pressurized / tighten by thrust retainer nut.

The bonnet-less valve shall be provided with sufficient ply of gland packings in the in-built stuffing box to seal the rear opening. The packings should be of graphited synthetic yarn to reduce the friction and offer higher life. Provision shall be made to enable tighten the gland packing by means of a pusher arrangement to minimize the leakage through the back of the valve. Replacement of gland packings should be possible in installed condition of the valve without there being line pressure.

The spindle should be double start / single threaded and non-rising type for compact & safe operation. Gate opening indicating arrangement should be provided to find out the extent of gate opening /closing. The operation of the valves shall be manual / motorized as specified elsewhere in the tender specification.

In case the valve is to be operated from a far then it shall be provided with joining couplings, extension spindle, spindle guides and mounting pedestal with suitable anchor bolts / anchor fasteners on the platform.

Materials of construction:

The material of construction for various components of valves shall be as under.

Body	: Ductile iron to BS 2789 Grade 420/12
Seal Retainer ring	: Stainless steel to ASTM A-351 Grade CF8
Inlet Seal / Rubber Seals / O rings	: EPDM Rubber
Knife gate	: Stainless Steel ASTM A 240 type 304
Spindle	: Stainless Steel ASTM A 276 type 304
Assembly bolts, nuts and fastener	: Stainless Steel ASTM A 276 type 304
Spindle nut	: Gunmetal / Phosphor Bronze / Brass
Bracket / Adapter plate	: Mild Steel to IS : 2062 grade A, Epoxy Painted
Packing	: Graphited synthetic yarn

8.26.5 Slide Gate Valve

(a) Valve shall be of wafer type with elastomer body sealing arrangement for bi-directional shut-off. The valves shall be designed to allow gland repacking without relieving line pressure.

(b) Body shall be two-piece cast construction bolted together with a mid-flange.

(c) The elastomer body seal shall be held in body such that it is kept away from direct impingement of any particles in the flow medium.

(d) The gate shall be provided with a beveled edge to facilitate positive closure of valve even with contaminated area.

(e) The body internals shall be countered such that settlement of particles in the media.

(f) Purge connection shall be provided optionally for these valves for cleaning the seating area.

(g) The material of construction of valve shall be as follows :

S. No.	Component	Material
(i)	Body	Ductile iron to BS 2789 Grade 420/12
(ii)	Gate	Stainless Steel: BS:970 Gr 304
(iii)	Stem	Stainless Steel: BS:970 Gr 304
(iv)	Body seal	Stainless Steel : BS:970 Gr 304
(v)	Hand wheel	Cast Iron : IS:210 Gr FG 260

8.26.6 Non Return Valve

(a) Type of Valve:

- For Raw Sewage, Clear water & Sludge Application: Only Swing type non return valve complying to IS 5312 is accepted for the individual delivery line & Common header of the pump. Swing door valves of size 600mm and above shall be of Multidoor type.

- For Process Air Application: Only Flap type non return valve is accepted for the individual delivery line & Common header of the Air Blower.

(b) The valves shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body. Hydraulic passages and doors shall be designed to avoid cavitation.

(c) Valves shall possess high speed closing characteristics and to be designed for minimum slam condition when closing.

(d) Valve of diameter greater than 450 mm shall be provided, in addition to others, supporting feet and jacking screws. Hinge pins / shaft shall preferably be square in section to ensure positive location of flaps and provide for secure fixing.

(e) Maximum pressure drop across the valve shall be 0.4 mwc. Maximum allowable leakage rate shall be 7cc/hr/mm diameter.

The material of construction of valve shall be as follows:

S. No	Component	Material
1.	Body and Door	Ductile iron to BS 2789 Grade 420/12
2.	Body and Door Ring	Stainless Steel : ASTM A743 CF8, BS970 Gr. 304 S11
3.	Hinge Pin	Stainless Steel : BS970 431 S29
4.	Bearings Bush	Stainless Steel backed Teflon
5.	Internal Fasteners	SS 316
6.	External Fasteners	High Tensile steel hot dipped galvanised

8.26.7 Telescopic Valves

The telescopic valve shall be a proprietary item of proven design manufactured in cast iron and adjustable to cater for variation in level.

The bell mouth height shall be controlled by a hand wheel operated from top of the chamber.

The bell mouth, pipe work, spindle and headstock shall be robustly constructed with adequate brackets of cast iron.

The bell mouth shall be connected by swept tees to a cast iron sludge outlet pipe of suitable diameter.

Component	Material
Bell Mouth	Cast Iron : IS:210 Gr. FG 260
Piping	Cast Iron : IS:210 Gr. FG 260
Spindle	Stainless Steel Gr. 304
Hand wheel	Cast Iron : IS:210 Gr. FG 260

8.26.8 Diaphragm Valves

Diaphragm valves shall be of the full-bore type to suit the maximum working pressure ratings required. Body ends shall be flanged and drilled to BS EN 1092-1/ BS 4504.

Indicators shall be supplied where specified showing both OPEN and CLOSED positions shall be supplied and provisions made for initiating the operation of remote indicator lights in the fully OPEN and CLOSED positions.

Valves used for toxic or hazardous fluids shall be provided with an additional `O' ring seal of nitrite rubber or other approved material.

Diaphragms shall be composed of moulded reinforced, flexible material attached by studs to the compressor. Diaphragm materials shall, where required, be composed of corrosion resistant material.

8.26.9 Isolating Cocks

For isolation of small bore pipe work tapings for instrumentation equipment etc., and for individual component isolation, the cocks shall be stainless steel, 0.25 turn ball or plug valve with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or near surface.

8.26.10 Pressure / Vacuum relief valves

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a preset maximum allowable pressure. The valves shall be drops tight under no flow conditions. Minimum of 3 nos of these valves of 150mm diameter shall be installed in the plant at digester and downstream piping.

Vacuum relief valves shall be capable of preventing the vacuum pressure to be developed in the system by allowing air entry. The valves shall be drops tight under no flow conditions.

The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.

Body ends shall be flanged and drilled to BS EN 1092-1/BS 4504.

8.26.11 Adjustable Weir Plates

The adjustable weir plates shall be manufactured from 5mm thick FRP or GRP Plates and to the approval of the Employers Representative.

Weir plates shall be complete with fixing nuts, bolts and washers and suitable for a total vertical adjustment of 100 mm through SS304 clamping plates. Fixings shall be designed for ease of accurately leveling the plates, securing the plates, and shall enable the plates to be adjusted during the life of the Works to accommodate differential settlement of the structure

8.26.12 Eccentric Structure Valve

(a) Valve shall be eccentric structure or horseshoe type disc and body. The valve shall be used for sludge line and flow control.

(b) The valves shall be for a smooth flux of fluid and suitable for fluid contained sludge and impurities at the treatment plant.

(c) The material of construction of valve shall be as follows:

S. No.	Component	Material
(i)	Body	Ductile iron to BS 2789 Grade 420/12
(ii)	Disc	Ductile iron with rubber lining
(iii)	Stem	Stainless Steel: BS:970 Gr 304
(iv)	Hand wheel	Cast Iron : IS:210 Gr FG 260

8.27 Domestic Water Pump sets

The Pump shall be of Centrifugal type, self priming and monoblock type. All the necessary piping with union, bends and tees shall be provided. Suction and discharge isolation valves and non-return valves on the discharge side shall be forged steel. Piping shall be as per IS: 1239 heavy class.

8.28 Approved Vendor/Manufacturer/Make List-Mechanical Equipment

	Consolidated Mechanical Equipment Vendor List	
S.No.	Item Description	Approved Vendor/ Manufacturer/ Make
1	Air Compressor	M/s Ingersol Rand
		M/s Kaeser
		M/s Kirloskar Pneumatic
		M/s Atlas Copco
2	Air Blowers (Roots Type)	M/s Swam
		M/s Everest
		M/s Usha compressors
3	Chlorination System	M/s Industrial Device
		M/s Pennwalt
		M/s Capital Controls
		M/s Chlorotech
4	Cranes (EOT, Hoists ,Jib cranes)	M/s W.H. Brady
		M/s Transpade Engineers
		M/s Safex Electromech
5	Centrifuge Decanter	M/s Pennwalt
		M/s Humboldt Wedag
		M/s GEA Westfalia
		M/s Andritz
		M/s Alpha Laval
6	Exhaust Fans	M/s Alstom
		M/s Flaktwood
		M/s Bajaj
		M/s Crompton
7	Flash Mixer/ Agitator	M/s Fibre & Fibre
		M/s Ceecons
		M/s Remi
		M/s Milton Roy
8	Horizontal Centrifugal Pumps	M/s KBL
		M/s Grundfos
		M/s Wilo
		M/s KSB
		M/s Pentair
	Submersible Pumps	M/s KSB
		M/s Xylem
		M/s Wilo
		M/s ABS Sulzer

	Consolidated Mechanical Equipment Vendor List	
S.No.	Item Description	Approved Vendor/ Manufacturer/ Make
		M/s Grundfos
		M/s Kishor
	Submersible Pumps-Tube installed	M/s ABS Sulzer
		M/s Xylem
		M/s Wilo
		M/s Grundfos
		M/s KSB
	Helical Rotor Screw Pumps	M/s Rotomac Pumps
		M/s Netzch technology
		M/s PD Pumps
		M/s Tushaco Pumps
		M/s Roto Pumps
	Chemical Dosing Pumps	M/s Milton Roy
		M/s Prominent
		M/s Swelore
9	Submersible Mixer	M/s ABS
		M/s Grundfos
		M/s KSB
		M/s ITT FLYGT-Xylem
10	Degrittor, Clarifiers and Thickener Mechanism	M/s Voltas
		M/s Triveni
		M/s Shivpad
		M/s Emco KCP
11	Butterfly Valve	M/s Pentair
		M/s Fouress
		M/s VAG Valves
		M/s AVK Valves
		M/s KBL
13	Sluice Gate Valve	M/s VAG
		M/s KBL
		M/s AVK
14	PP Valve	M/s Shenco
		M/s U N Polyvalves
15	Penstock Gates	M/s Jash
		M/s Yashwant
16	M.S- Cement Lined Pipes	M/s Jindal
		M/s PSL
		M/s Welspun

	Consolidated Mechanical Equipment Vendor List	
S.No.	Item Description	Approved Vendor/ Manufacturer/ Make
17	SS Pipes	M/s SAIL *
		M/s Jindal *
18	CI/DI/GI pipes	M/s Electrosteel
		M/s Lanco steel
		M/s Jindal
19	DI Fittings	M/s Kiswok
		M/s Kejriwal Castings
20	Motorised Weir Gates	M/s Jash
21	Chlorine Tonners	M/s ISGEC
		M/s Meenakshi Associates
22	Fine Bubble Diffusers	M/s Environmental Dynamics
		M/s OTT GMBH
		M/s Rehau
		M/s Southern scogen
23	Centrifugal Air Blowers	M/s Howden
		M/s Siemens
		M/s Neuros
		M/s Aerzen
24	Mechanical Screens (Bar/Drum type)	M/s Jash Engineering
		M/s Johnson screens
		M/s Headworks
		M/s Huber
25	Hot water Boiler	M/s Thermax Limited
		M/s Rakhoh
		M/s Cethar Limited
		M/s Cheema Boilers Ltd.
26	Electric Actuators	M/s Auma
		M/s Limitork
		M/s Rotork
27	Pneumatic Actuators	M/s Rotex
		M/s D Torque
		M/s Elomatic
28	UPVC & HDPE Pipes	M/s Jain Irrigation
		M/s Finloex
		M/s Duraline
		M/s Manikya Plastichem
		M/s Pennwalt Agro
		M/s Supreme

	Consolidated Mechanical Equipment Vendor List	
S.No.	Item Description	Approved Vendor/ Manufacturer/ Make
29	Motors	M/s Crompton Greaves Ltd
		M/s Marathon Electric (Alstom)
		M/s Kirloskar Electric company
		M/s Bharat Bijlee Ltd
		M/s ABB
30	Ball Valves	M/s BDK Engineers
		M/s Flowchem
		M/s Virgo
		M/s KBL
		M/s Microfinish
31	Knife Gate valves	M/s Jash Engineering (Scheute)
		M/s VAAS
		M/s Fouress
		M/s VAG
		M/s AVK
32	Diaphragm valves	Crane Process
		Microfinish
		BDK Engineers
		Leader
33	Eccentric Plug valves	M/s Dezurik
		M/s VAAS
34	Alum Rapid Induction Mixer	M/s Rite water solution
35	Air conditioner	M/s Bluestar
		M/s Voltas
36	Screw Impeller Submersible Pumps	M/s Hydrostal
		M/s Kubota Pumps
37	Direct Drive Turbo Blowers	M/s. Godrej
38	Geared Centrifugal Blower	M/s. Godrej
39	Disc Cloth Filter	M/s. Aqua Aerobic System Inc.
40	Sludge Thickner	M/s.
41	Centrifuge	M/s.

Note: Bidder shall select the equipments from makes listed above or approved equivalent. Approval is necessary from Bangalore Development Authority (BDA)/Competent Authority, For the Makes which are not listed above.

All the equipment, to be supplied under this contract have to be from experienced manufacturer. The equipment of only those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The naming of a manufacturer in this specification is not intended to eliminate competition or prohibit qualified manufacturers from offering equipment. Rather, the intent is to establish a standard of excellence for the material used, and to indicate a principle of operation desired.

In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following:

1. Demonstrate that the proposed makes are "Superior / Equivalent" to the approved makes.
2. Manufacturer involved in manufacture of specified equipment for at least 10 years before bid date
3. At least 5 successful installations commissioned in last 5 years before bid date and satisfactorily operating for at least one year before bid date. End user certificate shall be provided for the same.
4. Manufacturer to provide full contact information for each reference as part of technical bid

The Employer shall reserve the right to accept or reject the Bidder proposed makes.

8.29 Warranty

A. Comply with the requirements of each type of Equipment and specification mentioned elsewhere in this document.

B. Warrant all components to be free of defects in materials or workmanship for 12 months from date of satisfactory completion of performance test.

C. Individual warranties by component manufacturer in lieu of single source responsibility by the main Equipment manufacturer shall not be acceptable.

D. Items which fail during the warranty period, excluding expendable items, shall be replaced without cost to the Owner.

E. Provide manufacturer's guarantee and warranty certificates prior to equipment start-up.

8.30 Pipelines, Pipe work and Fittings

8.30.1 Applicable codes

The following codes and standards unless specified herein shall be referred to, or equivalent to the approval of Engineer.

8.30.2 Materials

IS : 210	Specification for grey iron casting
IS : 290	Specification for coal tar black paint
IS : 456	Code of practice for plain and reinforced concrete
IS : 458	Specification for pre cast concrete pipes (with and without reinforcement)
IS : 516	Method of test for strength of concrete
IS : 638	Specification for sheet rubber jointing and rubber insertion jointing
IS : 783	Code of practice for laying of concrete pipes
IS : 816	Code of practice for use of metal arc welding for general construction in mild steel
IS : 1367	Technical supply conditions for threaded steel fasteners
IS : 1387	General requirements for the supply of metallurgical materials
IS : 1500	Method for Brinell hardness test for metallic materials
IS : 1536	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage
IS : 1537	Specification for vertically cast iron pressure pipes for water, gas and sewage
IS : 1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage
IS : 1916	Specification for steel cylinder pipes with concrete lining and coating
IS : 2078	Method for tensile testing of grey cast iron
IS : 3597	Method of tests for concrete pipes
IS : 3658	Code of practice for liquid penetrant flow detection
IS : 5382	Specification for rubber sealing rings for gas mains, water mains and sewers
IS : 5504	Specification for spiral welded pipes
IS : 6587	Specification for spun hemp yarn
IS : 7322	Specification for specials for steel cylinder reinforced concrete pipes

8.30.3 Code of Practice

IS : 783	Code of practice for laying of concrete pipes
IS : 3114	Code of practice for laying of cast iron pipes
IS : 3764	Excavation work - Code of Safety
IS : 4127	Code of practice for laying of glazed stoneware pipes
IS : 5822	Code of practice for laying of electrically welded steel pipes for water supply.
IS : 6530	Code of practice for laying of asbestos cement pressure pipes.

8.30.4 Materials for Pipelines

Each pipeline shall be constructed in a material compatible with the fluid conveyed through that pipeline, i.e. the materials used in the pipes which are or can be in contact with the untreated or treated sewage, shall not contain any matter which could impart taste or odor or toxicity or otherwise be harmful to health or adversely affect the sewage conveyed. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

Pipe work and valve materials for the following duties shall be as follows or equivalent to the approval of the Engineer:

TABLE 8.1:PIPE WORK AND VALVE MATERIALS

Application / Location	Material
Chlorine: Drum connections Chlorine gas or liquid	 Cadmium plated 70/30 copper nickel CN 107, BS 2871 : Part 1 flanged or welded carbon steel, CAF flanged joints
Chlorine gas lines below atmospheric pressure Chlorine solution Polyelectrolyte dosing line Alum	Polyvinylidene fluoride (PVDF) with solvent welded or flanged joints/ Class E UPVC in concrete covered ducts outside building. Inside building and in exposed areas, rubber lined carbon steel Valves shall be globe type with forged steel bodies, monel spindles, stainless steel seats and PTFE gland packing or carbon steel, monel plug, PTFE sleeved plug UPVC/HDPE HDPE(High density polyethylene)
Water: Raw Sewage, Process sewage, dirty waste water, supernatant and treated Sewage/Effluent, Process sludge Service water MBR Permeate and Back pulse lines and associated piping, scour lines,	 Mild steel with mortar lining/gunniting (Beyond 1100mm diameter of pipe) or ductile iron (Up to 1100mm). GI (below 80mm), ductile iron (80mm and above). SS 316 (Sch 40)

Air: Process Air	Stainless steel AISI 316 (Sch 40) for exposed or buried service and for submerged service.

8.30.5 Ductile Iron Pipes and Fittings

8.30.5.1 Pipes and Fittings

(a) General

Ductile iron pressure pipes and fittings (Class K9) shall comply with IS 8329 and IS 9523. All fittings shall be socketed unless specified otherwise.

(b) Materials

The materials used in the manufacture pipes and fittings shall comply with IS 8329 and IS 9523.

(c) Tests

Tests on pipes and fittings shall be carried out in accordance with IS 8329 and IS 9523. The test method shall be submitted for approval of Engineer.

The Engineer shall be permitted free access to the place of manufacture for the purpose of examining, inspection and witnessing the testing of pipes and fittings.

8.30.5.2 Joints

(a) Spigot and Socket Joints

These shall have sockets which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS :5382-1969 (Latest edition/revision with amendments, if any).

(b) Flanged Joints

These shall comply with dimensions and drilling details shall be to BS EN 1092-1/BS: 4504 Table10/11 and16/11.All flanged joints between steel and ductile iron pipe work shall be electrically isolated joints. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All materials shall be supplied by a specialist manufacturer and be to the approval of the Engineer.

8.30.5.3 Linings

Ductile iron pipes and fittings shall have a cement mortar lining, in accordance with IS 11906 or ISO 4179.

Pipe linings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer. The Contractor may use specialist mortars, mortar additives or curing agents only with the approval of the Engineer.

Certain sections are amplified as follows:

No additives shall be used without the written approval of the Engineer, and shall be used strictly in accordance with the manufacturer‟s recommendations.

The minimum thickness of the lining at one point shall not be less than 4 mm.

8.30.5.4 Coating

(a) General

Ductile iron pipes and fittings shall be zinc coated with bitumen over coating, all in accordance with the following Specifications. Buried pipes and fittings shall also have a site or factory applied polythene sleeving. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Engineer.

(b) Zinc Coating

Zinc coating shall comply with ISO 8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130 g/m^2 as described in Clause 5.2 of ISO 8179.

(c) Bitumen Coating

Bitumen coating shall be of normal thickness 0.07 mm unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS 3416 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

(d) Polythene Sleeving

Where polythene sleeving is specified (generally for all buried DI pipes need sleeve covering) to be applied in addition to bitumen coating it shall comply with ISO 8180. Site applied sleeving shall be stored under cover, out of direct sunlight, and its exposure to sunlight shall be kept to a minimum. Pipes having a factory applied sleeving must be stored in the same conditions.

8.31 Reinforced Cement Concrete Pipes

8.31.1 Design

Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458.

8.32 Manufacturing

8.32.1 General

The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant clause of IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

The RCC pipes and collars/rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

The Engineer shall at all reasonable times have free access to the place where the pipes and collars/rubber rings are manufactured for the purpose of examining and testing the pipes and collars/ rubber rings and of witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes of that lot. The decision of the Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

8.32.2 Materials

For all materials Factory's test result, and written guarantee document with necessary analysis data shall be submitted to obtain the approval of the Engineer before carrying to sites.

8.32.2.1 Cement

Cement used for the manufacture of RCC pipes and collars shall conform to relevant IS codes. The use of pozzolana as an admixture to Portland cement shall not be permitted.

8.32.2.2 Aggregates

Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. The maximum size of aggregate should not exceed one third the thickness of the pipe or 20mm, whichever is smaller.

8.32.2.3 Mixing and Curing Water

Water shall be clean, colour less and free from objectionable quantities of organic matter, alkali, acid, salts, or other impurities that might reduce the strength, durability or other desirable qualities of concrete and mortar. Contractor shall submit water quality report before using it.

8.32.3 Reinforcement

Reinforcement used for the manufacture of the RCC pipes and collars shall be mild steel Grade I or medium tensile steel bars conforming to IS:432 (Part-1) or hard-drawn steel wire conforming to IS: 432 (part-2). Reinforcement cages for pipes and collars shall be as per relevant requirement of IS:458.

8.32.3.1 Concrete

Concrete used for the manufacture of RCC pipes and collars shall conform to IS: 456. The minimum cement content and minimum compressive strength of concrete shall be as per relevant requirements of IS: 458. Compressive strength tests shall be conducted on 15 cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

8.32.3.2 Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

8.45.3.3 Dimensions

The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS:458 for different classes of pipes.

The tolerances regarding overall length, internal diameter of pipes or sockets and barrel wall thickness shall be as per relevant clause of IS: 458.

8.45.3.4 Workmanship and Finish

Pipes shall be straight and free from cracks. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes upto 600mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.

The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between the Engineer and the manufacturer or supplier.

The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding.

The pipes shall be free from local dents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

The deviation from straight in any pipe throughout its effective length, tested by means of rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters 3 mm for every meter run.

8.32.4 Testing

All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.Engineer reserve the right to attend all testing.

During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS:458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

i) Hydrostatic test
ii) Three edge bearing test
iii) Absorption test
iv) Visual Examination

8.32.4.1 Sampling and Inspection

In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS: 458.

Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every pipe be selected till the requisite number is obtained, or being the integral part of N/n where N is the lot size and n is the sample size.

All pipes selected shall be inspected by Engineer for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS: 458.

All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

All result of tested data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the test shall be borne by the Contractor.

8.32.4.2 Marking

The following information shall be clearly marked on each pipe:

a) Internal and External diameter and length of pipe

b) Class of pipe

c) Date of manufacture and

d) Name of manufacturer or his registered trade-mark or both.

8.33 Jointing

8.33.1 General

Jointing of RCC pipes shall be done as per the requirements of following Employer's Requirements and as per the relevant IS standard. After jointing, extraneous material, if any, shall be removed from the inside of the pipe and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382. The pipe joint work must be done neatly and keep even slope and level for pipe laying works.

8.33.2 Spigot and Socket joint (Rigid)

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar which shall be rammed with caulking tool. This joint is used for low pressure pipe line.

8.33.3 Collar Joint (Rigid)

After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by the Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that the concentricity of the pipes and levels are not disturbed during this operation.

The collar shall then be place symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture of cement and sand to withstand any stress and prevent any water leakage, tempered with just sufficient water to have a consistency of the semi-dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be finished off with a fillet sloping at 45^0 to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by the Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

8.33.4 Flush Joint (Internal)

This joint shall be generally used for culvert pipes of 900 mm diameter and over. The ends of the pipes are specially shaped to form a self centering joint with an internal jointing space 13 mm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar mixed sufficiently dry to remain in position when forced with a trowel or rammer.

8.33.5 Flush Joint (External)

This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement mortar sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

8.33.6 Spigot and Socket (Semi-flexible)

This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar shall then be filled into the remaining annular space with a caulking tool.

8.33.7 Collar Joint (Semi-Flexible)

This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring which when compressed between the spigot and collar, seals the joint. Stiff mixture of cement mortar shall then be filled to withstand stress and prevent any water leakage, into the remaining annular space and rammed with a caulking tool.

8.33.8 Spigot and Socket Joint (Flexible)

The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The RCC pipes shall be of spigot and socket type and rubber rings shall be used, and the manufacturer's instructions shall be deemed to form a part of these Employer's Requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

8.33.9 Cleaning of Pipes

As soon as a stretch of RCC pipes has been laid complete from manhole to manhole or for a stretch as directed by the Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

It shall also be ascertained by contractor that each stretch from manhole to manhole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise.

8.34 Testing at work site

After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Engineer and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour. The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 liter/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the inspection shall be borne by the Contractor.

8.35 Steel Cylinder Pipes and Specials

8.35.1 Design

In general the design of steel cylinder pipes with concrete lining and coating shall conform to clause 8 of IS 1916. In addition to above, in case of buried pipe line, the pipe shall also be designed for the Earth load, and traffic load.

8.36 Manufacturing

8.36.1 General

Steel cylinder pipes and specials with concrete lining and coating shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained. The pipes and specials shall be inspected by Engineer at site and factory, and defects noticed, if any, such as protrusions, grooves, dents, notches, etc. shall be rectified, if agreed to by the Engineer. Care shall be taken that the resulting wall thickness does not become less than the minimum specified. If the wall thickness becomes less than the minimum specified, as per Table 1 of IS: 1916, the damaged portion should be cut out as cylinder and replaced by an undamaged piece of pipe at no extra cost to the Engineer.

The Engineer shall at all reasonable times have free access to the place where the pipes and specials are manufactured for the purpose of examining, inspection and testing the pipes and specials and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirement or in the relevant Indian Standards shall be performed by Supplier/Contractor at his own cost and in presence of the Engineer, if desired. For this sufficient notice before testing of the pipes and specials shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and specials of that lot. The decision of the Engineer in this matter shall be final and binding on the Contractor.

8.36.2 Materials

All material shall conform to Clause 7 of IS 1916.

8.36.3 Manufacturing Process

Steel cylinder pipes with concrete lining and coating shall be manufactured as per Clause No.9 of IS: 1916 and specials shall be manufactured as per Clause 7 of IS:7322. In case of spiral welded pipes, they shall be manufactured as per Clause 3 of IS: 5504. Internal lining shall be upto the full length of the pipes and specials. However, external coating shall be done leaving about 100 mm length of the pipes and specials from their ends. The internal lining and external coating to pipes and specials shall be done at factory. Before lining/coating by concrete/mortar the surface of pipes and specials shall be thoroughly cleaned. In the event that loose mill scale, tuberculation, or an accumulation of dirt, debris, oil or grease is present, it shall be removed from the surface by hand, by machine or both and given a coating of neat cement slurry.

8.36.4 Dimensions

The clear cover to the reinforcement whether steel cylinder or cage shall be not less than 9 mm for lining of pipe/special and 12 mm for coating of the pipe/special.

The permissible tolerance for diameter and length of pipe shall be as per Clause 4 of IS: 1916, whereas for diameter, arm length and angular deviation of specials the tolerance limit shall be as per Clause 6 of IS: 7322.

8.36.5 Workmanship and Finish

Workmanship and finish of pipe shall conform to Clause 4 of IS: 1916.

8.36.6 Testing

Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Engineer, the unlined specials shall be tested by penetration test as per IS: 3658 or other approved means.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the inspection shall be borne by the Contractor

8.36.7 Penetration Test

A suitable liquid penetrant (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrate time, the excess penetrant which remains on the surface, is removed. Then a light colored powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

8.36.8 Marking

The following information shall be clearly marked on each pipe and special:

i) Internal diameter, external diameter and thickness

ii) Class of pipe and special with its serial number

iii) Date of manufacture and

iv) Name of manufacturer or his registered trade mark or both

8.36.9 Jointing

8.36.10 General

Jointing of steel cylinder pipes and specials with concrete lining and coating be done as per the relevant IS. After jointing, extraneous material if any shall be removed from the inside of the pipe and special. The welding of joints for pipes and specials at work sites shall comply with 816. Electrodes used for welding shall comply with IS: 814.

8.36.11 Butt Welded Joint

After pipes and specials are laid in the trench, the faces of pipes/specials shall first be tack-welded alternately at one or more diametrically opposite pairs of points. After completing tack welding, full welding shall be carried out in suitable runs following a sequence of welding portions of segments diametrically opposite. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

8.36.12 Lap Welded Joint with Slip-in-ends

In the case of pipes with plain or slip-in-ends, swaged end of the steel cylinder may be formed by heating one of its ends and expanding it or rolling it out to the required shape. The minimum depth and maximum clearance between the swaged end and the plain end of pipes for field welding shall be provided as directed by the Engineer. Lap welding shall be done from the external face at the junction of pipe and socket. After jointing the exposed surface of the steel cylinder of pipes and specials shall be coated with M20 cement concrete of sufficient thickness so as to make it flush with the adjoining both inner and outer faces of pipes and specials. The gap in the internal lining at the joints shall be filled with cement mortar (1:2) for pipes and specials larger than 600 mm diameter. The lining/coating shall be done after the field test in the section has been successfully completed.

8.36.13 Flanged Joints

The flanges for steel cylinder pipes and specials shall be as per BS EN 1092-1/BS4504. Flanges shall be provided at the end of pipes or specials where valves, blank flanges etc. have to be introduced or flanged joints for the pipes are specified. The flanges shall have necessary bolt holes drilled. It might be necessary for contractor to follow the instructions and specifications given by the valve manufacturer. All bolts, nuts and packing material required for flanged joints shall be provided by the Contractor. Bolts and nuts shall conform to IS: 1367 whereas rubber gasket of required thickness shall conform to IS: 638.

The bolts shall be evenly tightened in comply with relevant BS standard. Random inspection shall be carried out by jointly the Engineer and the contractor.

8.36.14 Cleaning of pipes and specials

Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

8.36.15 Testing at work site

After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer. Water used for test shall be removed from pipes and not released to the excavated trenches.

Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be rewelded. Any cracked or defective pipes and

specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Engineer.

Proper arrangement of thrust blocks shall be provided during pressure testing or pipe laying works.

8.37 Steel Pipe work

Pipe/fitting material and dimensional standard shall conform to following :

Size mm (NB)	Material Specification (Steel)	Dimensional Standard
Pipes upto 150 mm	1239 PT, ERW, Black PT-1 HVY	1239 ERW
200 to 2400	2062	3589 – ERW 3589 for dimensions and minimum thickness. Pipe thickness shall be as per 2825
Elbows upto 25	ASTM–A 105	ANSI B 16.11 3000 # S.W.
40 to 150	ASTM-A 234 GR WPB	ANSI B 16.9
200 & above (meters)	2062	LR. BE. Sch 40 ANSI B 31.1
Coupling upto 25	ASTM-A 105	ANSI B 16.11 3000 # S.W.
Tees 40 to 200	ASTM – A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	IS 2062	IS 2825 (min. Pipe thickness)
Reducers upto 25	ASTM-A 105	ANSI B 16.11 3000 S.W.
40 to 200	ASTM-A 234 GR WPB	ANSI B 16.9 BE, Sch 40
Above 200	2062	IS 2825 (min. Thickness for larger pipes)
Flanges	2062	BS EN 1092-1
Bolts,Anchor Bolts and all nuts	SS316	1364
Gaskets All	638 (rubber) reinforced	3 mm thickness

Facilities shall be provided for draining the pipe system and releasing air.

The pipe work layout within pump stations shall have the approval of the pump manufacturer. Fluid velocities in suction pipe work leading to pumps shall not exceed 1.5 m/s. Fluid velocities in delivery pipe work leading from pumps shall not exceed 2.0 m/s.

The whole of the jointing work and materials necessary to fix and connect the pipes, including adequate and efficient pipe support shall be included in the Contract. The Contractor shall be responsible for ensuring that the internal surface of all pipe work is thoroughly cleaned before and during erection and before commissioning.

Cleaning shall include removal of all dirt, rust, scale and welding slag due to Site welding. Before dispatch from the manufacturer's works, the ends of the pipes, branch pipes, etc., shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until immediately prior to connecting adjacent pipes, valves or pumps. All small bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Employer.

Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

Flanges, if fabricated in segments shall be fully radiographed and stress relieved. If fabricated out of billets/bars by cold rolling, welded flanges shall be radiographed and normalized.

Protection for pipes laid underground shall be by coating and wrapping system giving a final coat thickness of 4.5 mm may be employed. Such protection shall comprise 1.5 mm of coal tar primer application on a thoroughly cleaned surface, to be followed with fiber glass wraps set in coal tar enamel coats conforming to American Water Works Association specification C/203/57 for a total thickness of 3 mm. Such lining shall meet a spark test to be approved with a holiday detector of 10000 Volts.

The Contractor shall indicate on his detailed drawings what thrust blocks are required to anchor pipe work supplied by him. Particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Employer.

Buried pipes shall in addition be designed to withstand external loading exerted by soil, water, and live loads as relevant. The external ground water shall be taken at ground level for design purposes. Saddle type/bracket type support wherever required shall be designed and supplied for the above ground pipe lines.

All pipe joints shall be of the butt welded type. End preparations and fabrication requirements shall generally conform to I.S. 2825. Flanges, if fabricated in segments, shall be fully radiographed and stress relieved.

Laying of welded steel pipes shall meet the requirements of I.S. 5822.

8.37.1 Welded Joints for Steel Pipes

Welding of joints in steel pipes shall be carried out manually by the metal arc welding process complying with AWWA Standard C206.

Before starting the welding of pipe joints in the Works the Contractor shall submit for the Engineer's approval details of the plant, methods and materials he proposes to use, including make and size of electrodes, number of runs, current strength and arrangements for air testing of individual joints.

Welding shall only be carried out by welders approved by the Engineer and each welder shall identify his work by means of a stenciled mark.

Welded joints other than for closing lengths shall be of the spherical spigot and socket type. For pipes of 675 mm diameter and smaller the pipe joint shall be welded externally. For pipes larger than 675 mm the pipe shall be welded internally and a sealing weld made externally.

All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by means of a wire brush and shall be left clean and dry. All scale and slag shall be removed from each weld run when it is completed. Pipes manufactured with longitudinal or spiral welds shall be lined up before jointing so that these welds are at least 15^{o} apart around the joint circumference.

For pipes larger than 900 mm diameter a triple run convex fillet weld shall be used. For pipes of 900 mm diameter or less a double run convex fillet weld shall be used. The minimum leg length of the fillet as deposited is to be equal to the full thickness of the pipe wall. The actual throat depth shall not be greater than 9/10th and not less than 7/10th of the minimum leg lengths as deposited. The depositing of the weld metal shall be carried out in such a manner as to ensure that all the welds have adequate root fusion and are of good clean metal free from cracks, gas holes, slag inclusions and all other impurities. The surface of the weld shall have an even contour with regular finish and shall indicate proper fusion with the parent metal. All slag shall be thoroughly removed after depositing each run of welding by light hammering with a chipping hammer followed by wire brushing. Any welds showing cracks or other cavities or in which the weld metal tends to overlap on to the parent metal without proper fusion or containing any other defects whatsoever shall be cut out and rewelded to the satisfaction of the Engineer at the Contractor's expense.

At closing lengths where two plain ended pipes are to be joined by a welded joint the gap between the two ends shall not exceed 75 mm. An external steel sleeve collar, of a thickness not less than that of the pipe itself and approximately 300 mm in length shall be placed centrally over the two ends to be jointed and the end of each pipe shall then be fillet welded to the sleeve collar in accordance with the above procedure.

No weld or adjacent parts of the pipe shall be painted prior to inspection by the Engineer.

8.37.2 Welder Performance Test

The Contractor shall submit for the Engineer's approval the names of persons whom he proposes to employ as welders with evidence that, as a minimum preliminary qualification, they have passed the qualifying tests prescribed in Clause 11 of BS 2633 and possessed certificates from an independent testing authority. The Engineer may further require any such person to perform satisfactory test welds under Site conditions and on pipes similar to those for use in the Works, before approving his employment as a welder. The Contractor shall maintain an up-to-date list of welders approved by the Engineer and if ordered by the Engineer he shall remove from the approved list any welder whose workmanship, as demonstrated by the results of air pressure tests on individual welded joints, is below a reasonable standard of quality of consistency in the Engineer's opinion.

8.37.3 Testing of Welded Joints

Where directed by the Engineer welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and re-welded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

8.37.4 Hydraulic Losses

Hazen-Williams Roughness Coefficient "C" for Head Loss calculation for Different Types of sludges in sewage shall be as per the table furnished below:

Solids in Sludge	Roughness Coefficient C	
	Raw Sludge	Digested Sludge
0	100	100
1	83	100
2	71	91
3	60	83
4	53	78
5	47	73

Solids in Sludge	Roughness Coefficient C	
	Raw Sludge	Digested Sludge
6	42	69
7	37	65
8	33	60
9	29	55
10	25	48

Manning's coefficient of roughness n for

(a) RCC channels shall be 0.018

(b) Cast Iron, Ductile Iron and Mild Steel with cement mortar lining shall be 0.011

a) K values for fittings

The losses in mwc shall be calculated as per empirical formulas .
K values for fittings shall be as given in below table

No.	Type of Fittings	Factor
1	Sudden contraction	0.5
2	Entrance shape well rounded	0.5
3	Elbow 90 degrees	1.0
4	Elbow 45 degrees	0.75
5	Elbow 22 degrees	0.5
6	Tee 90 degrees	1.5
7	Tee in straight pipe	0.3
8	Gate valve open	0.4
9	Valve with reducer and increaser	0.5
10	Globe valve	10.0
11	Angle	5.0
12	Swing check	2.5
13	Venturi meter	0.3
14	Orifice	1.0

8.37.5 Pipe work Protection

All underground steel piping shall have their external surfaces protected by application of one coal tar enamel coat, wrapping of fiberglass, one more coat of enamel and a final wrap of enamel impregnated fiberglass. Pipe surface shall be thoroughly cleaned by shot or sand blasting. Primer paint recommended by the enamel manufacturer for the grade of enamel used shall be applied over this cleaned surface within four hours of cleaning. The primer paint shall be thoroughly mixed and applied as recommended by the manufacturer and the coating shall be free of bubbles, globules, drips and runs. The primer shall be thoroughly dry before enamel is applied and the latter shall not be applied later than 3 days after application of primer. First flood coat of enamel shall be overlaid by a single spiral wrap of fiberglass overlapping at least 20 mm on pipe up to 250 mm diameter and 25 mm on larger diameter pipes. Enamel shall be heated slowly in clean kettles, equipped with indicating or recording thermometers (100°C to 350°C range), to the recommended temperature. The enamel shall be stirred continuously. It shall be seen

that fiberglass impregnates in the flood coat. Second coat of enamel and second wrap of bitumen impregnated fiberglass shall be applied in the same way. The total thickness of the coating shall not be less than 2.5 mm. Each end of the pipe left bare for a distance of 150 mm for welding shall be hand coated and wrapped after field welding is completed and hydro tested. Testing of pipe protection shall be done as directed by the Engineer using elcometers, coating thickness guages, and bond test and holiday detectors.

8.37.5.1 External protection

All underground pipework having a cover less than 1.5 m and more than 4.5 m shall be encased with M 15 concrete of minimum 200 mm thick all around.

All underground pipelines having a cover more than 1.5 m shall be externally protected by guiniting of minimum 40 mm thick as per specification.

All above ground and pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns.

8.37.6 Flexibility in Pipe work

The Contractor shall provide flexibility in the pipe work at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipe work where necessary to allow for some margin of error in the building work. Wherever possible flexible joints shall be provided (as per Engineer's directive) with tie bolts or other means to transfer longitudinal thrusts as a whole so that external anchorages may be kept to a minimum. Flexible joints (SS Bellows and Dismantling joints) shall also be provided for case of erection and future dismantling of all valves and Equipment. Particular care shall be taken to ensure that pipe work thrusts are not transmitted to machinery or associated apparatus.

The Contractor shall indicate on his detailed drawings what thrust blocks are required.

8.37.7 Puddle Flanges

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting form the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer prior approval.

8.37.8 Small Bore Pipes and Hoses

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joint or joints formed by solvent welding are proposed for any chemical line, a sufficient number of flanged or flexible joints shall be provided to enable the pipe work to be removed in sections without working from one end to the other of a particular run. Tees

and cocks shall also be provided at convenient points for the connection of a pressure water supply to flush pipe work through as required.

All pipes and hoses shall be labelled to enable individual lines to be identified throughout their run. Racks or trays shall be fixed to the duct walls or walls of tanks and buildings and the chemical pipes shall be fixed to these racks or trays with clips which can easily be removed without dismantling adjacent pipes. The Contract includes for the supply and fixing of all such racks or trays. Full details of the type of hoses, pipes and racks of trays proposed, shall be submitted at the time of tendering.

8.37.9 Support of Pipe work and Accessories

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. Valve, meters, strainers, and other devices mounted in the pipe work shall be supported independently of the pipes to which they connect.

All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by riveting or welding in preference to the use of castings.

No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

After the collars and boxes or other fitting have been fixed in position, the floors, walls and roof structure will be made good by the Contractor.

8.38 Cast Iron Pipes

8.38.1 Manufacturing

8.38.1.1 General

C.I. pipes and fittings shall be systematically checked for any manufacturing defects by experienced supervisors and a very high standard of quality shall be maintained.

Engineer shall at all reasonable times have free access to the place where the pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing.

All tests specified either in this Employer's Requirements or in the relevant Indian Standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes and fittings of that lot. The decision of the Engineer in this matter shall be final and binding of the Contractor and not subject to any arbitration or appeal.

8.38.1.2 Materials

The general requirements relating to the supply of material shall be as per IS: 1387.

The material for pipes and fittings shall be of good quality cast iron conforming to IS: 210 (Grade -FG 150).

8.38.1.3 Dimensions

The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per the relevant tables of IS: 1536/1537/1538 for different class of pipes and fittings.

The tolerances for pipes and fittings regarding dimensions and deviations from straight line in case of pipes shall be as per relevant IS codes.

The standard weight of uncoated pipes and fittings and the permissible tolerance shall be as per relevant IS codes.

8.38.1.4 Workmanship and Finish

The pipes and fittings shall be stripped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects, other than any unavoidable surface imperfections which result from the method of manufacture and which do not affect the use of the pipes in the opinion of Engineer.

The pipes and fittings shall be such that they could be cut, drilled or machined and may be accepted provided the hardness of the external unmachined surface does not exceed 230 HBS. In the case of spigot and socket pipes and fittings for lead joints, the socket shall be without the centering ring.

In the case of flanged pipes the flanges shall be at the right angles to the axis of the pipe and machined on face. The bolt holes shall be drilled and located symmetrically off the centre line. The bolt hole circle shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

8.38.1.5 Testing

a. Mechanical Tests

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

b. Brinell Hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

c. Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

d. Hydrostatic test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes for 15 seconds, they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

8.38.1.6 Coating

Coating shall not be applied to any pipe and fitting unless its surface is clean, dry and free from rust. All pipes and fittings shall be coated externally and internally with the same material, by dipping in a tar or suitable base bath. The pipe and fitting may be either preheated before dipping or the bath may be uniformly heated. The coating material shall set rapidly with good adherence and shall not scale off. In all instances where the coating material has a tar or similar base, it shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 65^{o} C, but not so brittle at a temperature of 0^{0}C as to chip off when scribed lightly with a penknife. In case of pipes and fittings which are imperfectly coated or where the coating does not set or conform to the required quality, the coating shall be removed and the pipes and fittings recoated.

In case the pipes are to be used for conveying potable water, the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or odour whatsoever to the potable water after disinfection and suitable washing of the mains.

8.38.1.7 Marking

Each pipe and fitting shall have cast, stamped or indelibly painted on it the following appropriate marks:

i) The nominal diameter.
ii) Flow direction and line marks for installation
iii) Class reference
iv) Mass of pipe
v) Date of manufacture and
vi) Manufacturer's name, initials or identification mark.

Marking shall be done as per relevant IS code.

8.39 Jointing

8.39.1 General

Jointing of CI pipes and fittings shall be done as per the requirements of following Employer's Requirements and as per the relevant IS. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382.

8.39.2 Tyton joints

In jointing cast iron spigot and socket pipes and fittings with tyton flexible joints the contractor shall take into account the manufacture's recommendations as to the methods and equipment to be used in assembling the joints. In particular the contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring as per IS: 5382, is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the pipe supplier or as otherwise directed by Engineer.

8.39.3 Flanged Pipes

The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber conforming to IS: 638, of thickness between 1.5 to 3 mm. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness.

Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternately. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

8.39.4 Cleaning of Pipes and Fittings

The Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

8.39.5 Testing at work site

After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test. Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until atleast two days have elapsed.

Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe as directed by the Engineer.

The duration of test shall not be less than 5 minutes. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be recaulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Engineer and the test shall be repeated to the satisfaction of the Engineer.

After the satisfactory completion of pressure test, the section of pipe line shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm3 /h as determined by the formula:

$$q_L = \frac{ND\sqrt{P}}{3.3}$$

Where,

q_L	=	The allowable leakage in cm^3/hr
N	=	Number of joints in the length of the pipeline
D	=	Diameter in mm, and
P	=	The average test pressure during the leakage test in Kg/cm^2

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to the Engineer until the leakage is within the specified allowance.

Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

After the tests mentioned above are completed to the satisfaction of the Engineer, the backfilling of trenches shall be done as per the Employer's Requirements specified elsewhere.

8.40 Un plasticised PVC Pipes and Fittings

Unplasticised polyvinyl chloride pipes, fittings and specials shall be to BS 3505 for potable water and BS 4346: Part 1 for fittings.

The pipes shall be of the spigot and socket type with approved gasket type flexible joint. The rubber gaskets shall be to BS 2494, Class C.

Where PVC pipes, fittings and specials are to be connected to cast iron, stainless steel or steel pipes, all metallic pipes, 'Viking Johnson' type flange adaptors or stepped couplings shall be used.

8.40.1 Polyethylene Pipes

Polyethylene pipes shall comply with BS 6437. The welding method shall be adapted to international standard and contractor shall obtain the approval of the Engineer before proceeding with such works.

8.40.2 Rubber Hosing

Rubber hosing shall conform to BS 5119, Type 2. It shall be capable of handling chlorine and sulphur dioxide solutions at a working pressure of 12 bar.

8.40.3 Copper Tubes and Fittings

Copper tubing and fittings for work above ground level shall comply with BS 2871 and BS 864: Part 2 respectively and be jointed with capillary joints. For underground location the copper pipe shall be to BS 2871: Part 1.

8.40.4 Flanged Joints

All flanges shall comply with BS EN 1092-1/BS 4504. The nominal pressure rating for particular flanges shall be at least equal to the highest pressure rating of the pipes or fittings to which they are attached, but with a minimum nominal pressure of PN 10. All flanges shall be provided with all necessary nuts, bolts, washers and gaskets. In general, valves shall have flanged body ends.

All flanged joints which are buried or in chambers shall be protected with Densomastic and Densotape wrapping, applied in accordance with the manufacturer's instructions.

Flanges shall be installed on the pipes in the factory and field welding of flanges shall only be allowed with the approval of the Engineer.

Where pipework outside pumping stations and surge vessel chambers is cathodically protected, an insulated flange shall be incorporated at the first flange inside the structure. These flanges shall be tested to ensure that electrical insulation is achieved.

8.40.5 Gaskets and Joint Rings

Joint rings shall be manufactured to conform with BS 2494 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80^{o}C.

Gaskets may be inside the bolt circle type and shall comply with BS 4865: Part 1. Alternatively the gasket shall be to the full diameter of the flange, drilled to suit the appropriate bolt provisions.

Chloroprene rubber with a hardness of 71 to 80 IRHD shall be used.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any soluble constituent, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint shall be made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

8.40.6 Flexible Couplings and Flange Adaptors

Flexible couplings and flange adaptors shall be of the Viking Johnson or similar approved pattern and be assembled in accordance with the manufacturer's instructions and protected, if buried or in chambers with Densomastic and Densotape wrapping applied in accordance with the manufacturers' instructions. Flexible joints shall be harnessed or tied where necessary

8.41 Storage & Shipment

8.41.1 Protection of Pipes and Fittings for Shipment

Except where otherwise specified all items shall have received their complete protective coatings before dispatch from the manufacturer's works and shall be additionally protected by approved means for the period of transit, storage and erection, against corrosion and accidental damage.

For the protection of pipe linings and in particular for protecting cement mortar linings from drying out, protective metal or timber discs shall be fitted over the ends of pipes and fittings. Similar timber protective discs shall be attached to all flanges of pipes and fittings, by means of bolts specifically provided for the purpose and which shall be discarded when the item is incorporated in the Works. The sleeves and flanges of flexible joints shall be wired together in suitable bundles.

8.41.2 Storage of Pipeline Materials

Pipes and fittings shall be stored raised off the ground, and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one another and shall not be stacked more than four pipes high or two pipes high in the case of pipes of 500 mm diameter or over. Special care shall be taken to ensure that flexible pipes are cradled and supported in a manner that prevents any distortion of the pipes.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Storage areas shall be carefully set out to facilitate unloading, and checking of materials with different consignments stacked or stored separately with identification marks clearly visible.

Where items to be stored have a limited shelf life or require special storage arrangements, the method of storage shall be to the approval of the Engineer and in accordance with the manufacturer's instructions.

All pipes and fittings supplied as spares shall have end covers which are proof against the entry of sand and vermin. Mortar lined pipes and fittings shall have end covers which form a complete seal, provision being made to accommodate the effects of temperature changes. Pipes and fittings supplied as spares shall have a temporary white external finish and shall be stored sheltered from the direct rays of the sun.

End covers and protection shall not be removed until incorporation of the pipes and fittings into the Works.

8.42 Transportation of Pipes and Fittings

Any vehicle on which pipes are transported shall have a body of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads properly secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.

Approved slings shall be used and all hooks and dogs and other metal devices shall be well padded. Hooks engaged on the inner wall surface at pipe ends shall not be used. Steadying ropes shall be employed. The positions of lifting slings shall ensure that stresses and tendency towards deformation in the pipes are kept at a minimum.

Pipe handling equipment shall be maintained in good repair and any equipment which in the opinion of the Engineer may cause damage to the pipes shall be discarded.

Under no circumstances shall pipes be dropped, be allowed to strike one other, be rolled freely or dragged along the ground.

8.43 Inspection of Pipes and Fittings

Before incorporating into the Works each pipe shall be brushed out and carefully examined for soundness. Damaged pipes which in the opinion of the Engineer cannot be satisfactorily repaired shall be rejected and removed from Site.

Damage to pipe coatings or linings shall be repaired to the satisfaction of the Engineer.

8.43.1 Built-in Pipe work and other Plant

The pipes and other Plant in water retaining structures shall, wherever possible, be built in as the work on the structure proceeds. The Contractor shall ensure that delivery of the requisite pipe work and other Plant is in accordance with the requirements of the programme.

Where a pipe subject to thrust passes through a concrete structure or where an external seal is required, a puddle flange shall be used. The puddle flange dimensions shall be to BS EN 1092-1/BS 4504 but shall be undrilled. The exterior of the pipe shall be cement washed symmetrically about the puddle flange by the manufacturer for a length at least equivalent to the thickness of the wall through which it passes.

The Contractor shall be responsible through every stage of the Works for checking the correctness of the setting of built-in Plant and shall satisfy himself they are positioned in accordance with his approved drawings.

8.44 Pipe laying

8.44.1 Carting & Handling

Pipes and fittings /specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by the Engineer. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to other. In case of spigot socket pipes, care should be taken regarding orientation of pipes while unloading. As far as possible pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

8.44.2 Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m.

Fittings/Specials shall be stacked under cover and separated from pipes.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they are not left out on the ground in the sun or overnight under heavy frost or snow conditions.

8.45 Laying

8.45.1 Excavation

Before excavating the trench the alignment of pipeline shall be approved by the Engineer. The excavation of trenches and pits for manholes/ chambers shall be carried out in accordance with the Employer"s Requirements described elsewhere and shall be done such that it does not get far ahead of the laying operation as approved by the Engineer.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of the construction work and until it is safe for the traffic to use the roadways. The relevant Indian Standards and the rules and regulations of local authorities in regards to safety provisions shall be observed.

Suitable fencing shall be provided along the sides of trenches and pits. The posts of fencing shall be of timber securely fixed in the ground not more than 3 m apart and they shall not be less than 75 mm in diameter or less than 1.2m above surface of the ground. There shall be two rails, one near the top of the post and the other about 450mm above the ground and each shall be from 50mm to 70mm in diameter and sufficiently long to run from post to post to which they shall be bound with strong rope. The method of projecting rails beyond the post and tying them together where they meet will not be allowed on any account. All along the edges of the excavation trenches a bank of earth about 1.2 m high shall be formed where required by the Engineer for further protection.

The road metal and also the rubble packing shall first be stripped off for the whole width of the trench/pit and separately deposited in such place or places as may be determined by the Engineer.

During excavation, large stones and rubble shall be separated and removed from the excavated soil and stacked separately. The material from excavation shall be deposited on either side of the trench leaving adequate clear distance from the edges of the trench and pit, or as may be necessary to prevent the sides of the trench pit to slip or fall, or at such a distance and in such a manner as to avoid covering fire hydrants, sluice valves, manholes and covers etc. and so as to avoid abutting the wall or structure or causing inconvenience to the public and other service organizations or otherwise as the Engineer may direct.

Contractor shall take into account additional excavation if any as the Engineer may require in order locating the position of water pipes, drains, sewers etc. or any other works which may be met with, in or about the

excavation of trenches/pits while quoting the rates for excavation of trenches /pits while quoting the rates of excavation. Such service lines if met with during excavation shall be properly maintained by Contractor, by means of shoring, strutting, planking over, padding or otherwise as the Engineer may direct, and shall be protected by the Contractor from damage during the progress of the work. All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure /pipe line of water, gas, sewage etc.

Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than the minimum requirement. In case additional width is required it shall be provided only in the top portion from the ground level upto 300 mm above the top of pipe. If any extra width is provided in the area below this portion, Contractor shall have to provide remedial measures in the form of lime concrete or rubble masonry otherwise at the discretion and to the satisfaction of the Engineer. If rock is met with, it shall be removed to 15 cm below the bottom of pipes and fittings/specials and the space resulting shall be refilled with granular materials and properly consolidated. Bottom of trenches/pits shall be saturated with water well rammed wherever the Engineer may consider it necessary to do so.

Wherever a socket or collar of pipe or fitting/ special occurs, a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such grip shall be of sufficient size in every respect to admit the hand all around the socket in order to make the joint and the grip shall be maintained clear until the joint has been approved by the Engineer.

When welding is to be carried out with the pipes and specials in the trench, additional excavation of not more than 60cm in depth and 90 cm in length shall be made at joints in order to facilitate welding.

The excess excavated material shall be carried away from site of works to a place up to a distance as directed by the Engineer. This shall be done immediately so as not to cause any inconvenience to the public or traffic. If the instructions from Engineer are not implemented within seven days from the date of instructions to cart the materials and to clear the site, the same shall be carried out by the Engineer and any claim or dispute shall not be entertained in this respect.

8.45.2 Dewatering

During the excavation, if subsoil water is met with Contractor shall provide necessary equipment and labourers for dewatering the trenches. The Contractor shall also make necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by the Engineer. In no case the water shall be allowed to spread over the adjoining area. Before discharging this water into public sewer/drain, the Contractor shall take necessary permission from the local authorities.

8.45.3 Special Foundation in Poor Soil

Where the bottom of the trench and sub grade is found to consist of material which is unstable to such a degree that in the opinion of the Engineer, it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly, a suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant drawings to be prepared by the Contractor and as instructed by the Engineer shall be constructed.

8.45.4 Wooden Shoring

Contractor shall suitably design polling boards, waling and struts to meet different soil conditions that might be encountered in excavating trenches/pits. The horizontal and vertical spacing of struts shall be such that not only the sides of trenches shall be prevented from collapse but also easy lowering of pipe in trenches shall be ensured without creating undue obstructions for the excavation of the work. Any inconvenience and/or delay that might be caused in lowering pipes in trenches as a result of adopting improper spacing of struts by Contractor shall be his sole responsibility. No part of shoring shall at any time be removed by Contractor without obtaining permission from the Engineer. While taking out shoring planks the hollows of any form must simultaneously be filled in with soft earth well rammed with rammers and with water.

The Engineer may order portions of shoring to be left in the trenches /pits at such places, where it is found absolutely necessary to do so to avoid any damage which may be caused to buildings, cables, gas mains, water mains, sewers etc. in close proximity of the excavation, by pulling out the shoring from the excavations. The Contractor shall not claim, on any reason whatsoever, for the shoring which may have been left in by him at his own discretion.

8.45.5 Steel Plate Shoring

Where the subsoil conditions are expected to be of a soft and unstable character in trench/pit excavation, the normal method of timbering may prove insufficient to avoid subsidence of the adjoining road surfaces and other services. In such circumstances, the Contractor will be required to use steel trench sheeting or sheet piling adequately supported by timber struts, waling etc., as per the instructions, manner and method directed by the Engineer. Contractor shall supply pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Employer's Requirements.

8.45.6 Boning Staves and Sight Rails

In laying the pipes and fittings/ specials the centre for each manhole / chamber or pipeline shall be marked by a peg. Contractor shall dig holes for and set up two posts (about 100 x 100 x 1800 mm) at each manhole/chamber or junction of pipelines at nearly equal distance from the peg and at sufficient distances there from to be well clear of all intended excavation, so arranged that a sight rail when fixed at a certain level against the post shall cross the centre line of the manhole/chamber or pipe lines. The sight rail shall not in any case be more than 30 m apart; intermediate rails shall be put up if directed by the Engineer.

Boning staves of 75 mm x 50 mm size shall be prepared by Contractor in various lengths, each length being of a certain whole number of meters and with a fixed tee head and fixed intermediate cross pieces, each about 300 mm long. The top-edge of the cross piece must be fixed below the top-edge of the tee-head at a distance equal to the outside diameter of the pipe or the thickness of the concrete bed to be laid as the case may be. The top of cross pieces shall indicate different levels such as excavation for pipe line, top of concrete bed, top of the pipe etc. as the case may be.

The sight rail of size 250 mm x 40 mm shall be screwed with the top edge resting against the level marks. The center line of the pipe shall be marked on the rail and this mark shall denote also the meeting point of the center lines of any converging pipes. A line drawn from the top edge of one rail to the top edge of the next rail shall be vertically parallel with the bed of the pipe, and the depth of the bed of pipe at any intermediate point may be determined by letting down the selected boning staff until the tee head comes in the line of sight from rail to rail.

The post and rails shall be perfectly square and planed smooth on all sides and edges. The rails shall be painted white on both sides, and the tee-heads and cross-piece of the boning staves shall be painted black.

For the pipes converging to a manhole/chamber at various levels, there shall be a rail fixed for every different level. When a rail comes within 0.60 M of the surface of the ground, a higher sight-rail shall be fixed for use with the rail over the next point.

The posts and rails shall in no case be removed until the trench is excavated, the pipes are laid and the Engineer gives permission to proceed with the backfilling.

8.45.7 Laying of Pipes and Fittings/Specials

All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure/pipeline of water, gas, sewage etc. After excavation of trenches, pipes shall not be lowered unless the dimensions of trenches and bedding work for pipes at the bottom of the trenches are approved and measured by Employer /Engineer. Pipes and fittings/specials shall be carefully lowered in the trenches. Special arrangements such as cranes, tripods with chain pulley block for lowering the pipes and fittings/specials shall be made by Contractor. In no case pipes and fittings/specials shall be dropped. Slings of canvas or equally non-abrasive material of suitable width or special attachment to fit the ends of pipes and fittings/specials shall be used to lift and lower the coated pipes and fittings/specials. The pipes and fittings /specials shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. If doubt persists, further confirmation shall be done by pouring a little kerosene/dye on the inside of the pipe at the suspected spot. No sign of kerosene/dye should appear on the outside surface. Pipes and fittings/specials damaged during lowering or aligning shall be rejected by the Engineer.

All the pipes are to be laid perfectly true both in alignment and to gradient specified. In case of spigot and socket pipe the socket end of the pipe shall face upstream, except when the pipeline runs uphill in which case the socket ends should face the upgrade. The laying of pipes shall always proceed upgrade of a slope. After placing a pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to required gradient. The pipes shall be secured in place with approved backfill material tamped under it except at the socket. Pipes and fittings/specials which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipes and fittings/specials of proper dimensions to ensure such uniform space. Precautions shall be taken to prevent dirt from entering the jointing space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Engineer. During the period that the plug is on, the Contractor shall take proper precautions against floating of the pipe owing to entry of water into the trench. Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted the deflection allowed at joints shall not exceed $2\ ^{1}/_{2}0$. In case of pipes, with joint to be made with loose collars, the collars shall be slipped on before the next pipe is laid. The pipes shall be laid such that the marking on pipes appears at the top of the pipes.

The cutting of pipe for inserting valves, fittings, or specials shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used.

8.45.8 Thrust Blocks

Thrust Blocks shall be provided for all piping works, to counteract hydraulic thrust, at places wherever directed by the Engineer as per approved design.

8.45.9 Jointing

Jointing for pipes and fittings/specials shall be done in accordance with the relevant Employer's Requirements depending upon the type of pipes being used.

8.45.10 Testing and Commissioning

Testing and commissioning of pipes shall be done in accordance with the relevant Employer's Requirements.

8.45.11 Backfilling

Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipeline. The tamping around the pipe shall be done by hand or other hand-operated mechanical means. The water content of the soil shall be as near the optimum moisture content as possible. Filling of the trench

shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressure does not occur. Backfilling shall be done in layers not exceeding 30 cm. Each layer shall be consolidated by watering, ramming, care bring taken to avoid damage to the pipeline. In case of the mild steel pipes/specials, the spiders provided during assembly and welding shall be retained until the trench is refilled and consolidated. Where timbers are placed under the pipeline to aid alignment, these timbers shall be removed before backfilling.

The Contractor is requested to provide the method of Backfilling compaction test and evaluation value and obtain the approval from the Engineer.

8.45.12 Reinstatement of Road/Footpath

Reinstatement of road/footpath shall be done as per the requirements of local authorities and the Employer's Requirements after completion of work.

8.45.13 Clearing of Site

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by the Engineer and the construction site left clean to the satisfaction of the Engineer.

8.46 Disinfection of Water Mains

The mains intended for potable water supplies should be disinfected before commissioning them for use. Special care should be take to ensure disinfection of new mains. Among possible sources of contamination are sewer drainage, contaminated soil in the trench, contamination from workmen or their equipment of both and unavoidable foreign material present in the trench during construction.

Education of crew members as to the need for avoiding contamination of the main during construction is fundamental. Contractors and workmen should be thoroughly familiar with all pertinent state and local requirements governing installation of mains. All sewers, water mains and other underground conduits should be located prior to construction relocated, if necessary, to prevent contamination during construction. Pipe should be strung on high ground. At all times when construction is not actually in progress, watertight plugs should be installed in all pipe openings. Gunny sack and rags are not adequate. Provision should be made to pump any other water that might collect in the trench. Special care should be taken to avoid contamination of valves, fittings, and pipe interiors, both before and during construction each of them should be inspected and, if necessary, cleaned before installation.

After pressure testing the main, it should be flushed with clean water at sufficient velocity to remove all dirt and other foreign materials in the constructed pipeline. When this process has been completed, disinfection (using liquid chlorine, sodium or calcium hypochlorite) should proceed by one of the recommended methods as described in the following

8.46.1 Continuous Feed

In this method, water from the distribution system or other approved source and the chlorine is fed at constant rate into the new main at a concentration of atleast 20 mg/1. A property adjusted hypochlorite solution injected into the main with a hypochlorinator, or liquid chlorine injected into the main through a solution feed chlorinator and booster pump may be used. The chlorine residual should be checked at intervals to ensure that the proper level is maintained. Chlorine application should continue until the entire main is filled. All valves, hydrants, etc., along the main should be operated to ensure their proper disinfection. The water should remain in the main for a minimum of 24 hours. Following the 24 hours period no less than 10 mg/1 chlorine residual should remain in the main.

The Contractor is requested to provide photo and take a record the value of chlorine residual at starting point and after 24 hours before completion of work.

The Engineer shall jointly check the test at sites. If the value is insufficient, the disinfections work shall be repeated until satisfactory results are achieved.

Waste chlorine residual water must be neutralized before it is discharged to any drainage.

8.46.2 Slug Method

In this method a continuous flow of water is fed with a constant dose of chlorine (as in the previous method) but with rates proportioned to give a chlorine concentration of at least 300 mg/1. The chlorine is applied continuously for a period of time to provide a column of chlorinated water that contacts all interior surfaces of the main for a period of at least 3 hours. As the slug passes tees, crosses, etc., proper valves shall be operated to ensure their disinfection. This method is used principally for large diameter mains where continuous feed is impractical.

Regardless of the method used, it is necessary to make certain that backflow of the strong chlorine solution into the supplying line does not occur. Following the prescribed contact period, the chlorinated water should be flushed to waste until the remaining water has a chlorine residual approximating that throughout the rest of the system. Bacteriological tests as prescribed by the authorities should be taken, and if the results fail to meet minimum standards, the disinfecting procedure should be repeated and the results again tested before placing the main in service.

If continuous feed method is difficult to apply, Retention Method shall be considered as alternative way.

The area or pipe line to be disinfected shall be fed with chlorine solution from up stream under flowing water condition, and then the area shall be blocked after make sure to reaching more than 20 mg/l. The chlorine solution fed in the pipeline needs to wait for 1 day before starting measurement of residual chlorine. After 3 days later, the chlorine residual value shall be tested at sampling points at up stream and at downstream near to end to check whether the value is in range or not.

The Contractor shall provide photo and take a record the value of chlorine residual at starting point and after 24 hours before completion of work.

The Engineer shall jointly check the test at sites. If the value is insufficient, the disinfections work shall be repeated until satisfactory results are achieved.

Waste chlorine residual water must be neutralized before it is discharged to any drainage, as approved by Engineer.

8.47 Disc Cloth filter:

Shall adhere to the tender clauses and specifications

Disc/Cloth Media Filter shall be fixed with the following required accessories: Centertubes, Disc, Backwash Shoes, Brushes, Interconnecting pipes, Valves, Backwash Pumps. etc.,

Disc Cloth Filter installed shall be able to produce TSS value as specified in the bid document

Nominal filtration rate 10 microns
Each filter basin fitted with 304 SS mounting brackets

8.48 Sludge Thickener:

Shall adhere to the tender clauses and specifications

8.49 Centrifuge Unit:

Shall adhere to the tender clauses and specifications

End of Part 8

PART 10A

CIVIL & STRUCTURAL WORKS

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SECTION 1

SITE CLEARANCE (CLEARING AND GRUBBING)

SECTION 1

SITE CLEARANCE (CLEARING AND GRUBBING)

1.0 Scope

This work shall consist of cutting, removing and disposing of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil not exceeding 150 mm in thickness, rubbish etc., from the area of Works which in the opinion of the Engineer are unsuitable for incorporation in the Works, and such other areas as may be specified on the Drawings or by the Engineer. It shall include necessary excavation, backfilling of pits resulting from uprooting of trees and stumps to required compaction, handling, salvaging, and disposal of cleared materials. Clearing and grubbing shall be performed in advance of earthwork operations and in accordance with the requirements of these Specifications.

1.1 Preservation of Property/Amenities

Trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, sewers and all facilities within or adjacent to the site which are not to be disturbed shall be protected from injury or damage. The Contractor shall provide and install at his own expense, suitable safeguards approved by the Engineer for this purpose.

During clearing and grubbing, the Contractor shall take all adequate precautions against soil erosion, water pollution, etc., and where required, undertake additional Works to that effect vide relevant Clauses of section 3 Before start of operations, the Contractor shall submit to the Engineer for approval, his work plan including the procedure to be followed for disposal of waste materials, etc., and the schedules for carrying out temporary and permanent erosion control Works as stipulated in Section 3.

1.2 Methods, Tools and Equipment

Only such methods, tools and equipment as are approved by the Engineer and which will not affect the property to be preserved shall be adopted for the Work. If the area has thick vegetation / roots / trees, a crawler or pneumatic tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case these fall within 500 mm of the subgrade / foundation / bed level. Also, all vegetation such as roots, under-growths, grass and other deleterious matter unsuitable for incorporation in the Work shall be removed between fill lines to the satisfaction of the Engineer. On the areas beyond these limits, trees and stumps required to be removed as directed by the Engineer shall be cut down to 1 m below ground level so that these do not present any unsightly appearance.

All branches of trees extending above the roadway shall be trimmed as directed by the Engineer.

All excavations below the general ground level arising out of the removal of trees, stumps, etc., shall be filled with suitable material and compacted thoroughly so as to make the surface as these points conform to the surrounding area.

Ant-hills both above and below the ground, as are liable to collapse and obstruct free subsoil water flow shall be removed and their workings, which may extend to several meters, shall be suitably treated.

1.3 Disposal of Materials

All materials arising from clearing and grubbing operations shall be the property of Employer and shall be disposed of by the Contractor as hereinafter provided or directed by the Engineer.

Trunks and stumps of trees shall be cleaned of limbs and roots and stacked. Also boulders, stones and other materials usable in construction shall be neatly stacked as directed by the Engineer. Stacking stumps, boulders, stones etc., shall be done at specified spots with all lifts and lead.

All products of clearing and grubbing which, in the opinion of the Engineer, cannot be used or auctioned shall be cleared away from the site in a manner as directed by the Engineer. Care shall be taken to see that unsuitable waste materials are disposed off in such a manner that there is no likelihood of these getting mixed up with the materials meant for construction.

1.4 Measurements for Payment

Clearing and grubbing shall be measured on area basis in terms of hectares. Clearing and grubbing of borrow areas shall be deemed to be a part of Works preparatory to embankment construction and shall be deemed to have been included in the rates quoted for the embankment construction item and no separate payment shall be made for the same. Cutting of trees up to 300 mm in girth including removal of stumps and roots, and trimming of branches of trees extending above the roadway shall be considered incidental to the clearing and grubbing operations. Removal of stumps left over after trees have been cut by any other agency shall also be considered incidental to the clearing and grubbing operations.

Cutting, including removal of stumps and roots of trees of girth above 300 mm and backfilling to required compaction shall be measured in terms of number according to the sizes given below:

1. Above 300 mm to 600 mm;
2. Above 600 mm to 900 mm;
3. Above 900 mm to 1800 mm; and
4. Above 1800 mm.

For this purpose, the girth shall be measured at a height of 1 m above ground or at the top of the stump if the height of the stump is less than 1 m from the ground.

1.5 Rates

The Contract unit rates for the various items of clearing and grubbing shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools,

equipment and incidentals necessary to complete the work. These will also include removal of stumps of trees less than 300 mm in girth as well as stumps left over after cutting of trees carried out by another agency, excavation and back-filling to required density, where necessary, and handling, salvaging, piling and disposing of the cleared materials with all lifts and leads.

1.5.1 The Contract unit rates for cutting (including removal of stumps and roots) of trees of girth above 300 mm shall include excavation and back-filling to required compaction, handling, salvaging, piling and disposing of the cleared materials with all lifts and lead.

1.5.2 Where a Contract does not include separate items of clearing and grubbing, the same shall be considered incidental to the earthwork items and the Contract unit prices for the same shall be considered as including clearing and grubbing operations.

End of Section 1

SECTION 2

DISMANTLING AND DEMOLITION

SECTION 2

DISMANTLING AND DEMOLITION

2.1 Scope

This work shall consist of removing, as hereinafter set forth, existing buildings, roofs, ceiling, flooring and paving, concrete and brick roofs and suspended floors, walls and columns, reinforced concrete and brick work, partitions, wood work, steel and iron work, doors and windows, pipes and sewer lines, posts or struts, fencing wire mesh, glazing, culverts, bridges, pavements, kerbs and other structures like guardrails, utility services, catch basins, inlets, etc., which are in place but interfere with the new construction or are not suitable to remain in place, and of salvaging and disposing of the resulting materials and back filling the resulting trenches and pits.

Existing culverts, bridges, pavements and other structures which are within the highway and which are designated for removal, shall be removed up to the limits and extent specified in the Drawings or as indicated by the Engineer.

Dismantling and removal operations shall be carried out with such equipment and in such a manner as to leave undisturbed, adjacent pavement, structures and any other work to be left in place.

All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

2.2 Applicable Codes

IS: 1200-1974 (Part: XVIII)	Method of Measurements of Building and Civil Engineering Works. Demolition and Dismantling (Reaffirmed 1992) (3rd Revision).
IS: 4130-1991	Demolition of Buildings - Code of Safety (2nd Revision).

2.3 Terminology

The term **'Dismantling'** implies carefully separating the parts without damage and removing.

This may consist of dismantling one or more parts of the structure as specified or shown on the Drawings.

The term **'Demolition'** implies breaking up. This shall consist of demolishing whole or part of work including all relevant items as specified or shown on the Drawings.

2.4 Buildings

2.4.1 Precautions

All materials obtained from dismantling or demolition shall be the property of the Employer unless otherwise specified and shall be kept in safe custody until they are handed over to the Engineer.

The demolition shall always be well planned before hand and shall generally be done in reverse order of the one in which the structure was constructed. The operations shall be got approved from the Engineer-In-Charge before starting the work.

Due care shall be taken to maintain the safety measures prescribed in IS: 4130.

Necessary propping, shoring and or under pinning shall be provided to ensure the safety of the adjoining work or property before dismantling and demolishing is taken up and the work shall be carried out in such a way that no damage is caused to the adjoining work or property. Wherever specified, temporary enclosures or partitions shall also be provided, as directed by the Engineer.

Necessary precautions shall be taken to keep down the dust nuisance to the minimum.

Dismantling shall be done in a systemic manner. All materials which are likely to be damaged by dropping from a height or by demolishing roofs, masonry etc. shall be carefully removed first. The dismantled articles shall be removed manually or otherwise, lowered to the ground (and not thrown) and then properly stacked as directed by the Engineer.

Where existing fixing is done by nails, screws, bolts, rivets, etc., dismantling shall be done by taking out the fixing with proper tools and not by tearing or ripping off.

Any serviceable material, obtained during dismantling or demolition, shall be separated out and stacked properly as directed by the Engineer within a lead of 50 m. All unserviceable materials rubbish etc. shall be disposed off as directed by the Engineer.

The Contractor shall maintain / disconnect existing services, whether temporary or permanent, where required by the Engineer.

2.4.2 Measurements

All work shall be measured net in the decimal system, as fixed in its place, subject to the following limits, unless otherwise stated hereinafter.

1. Dimensions shall be measured correct to a cm.
2. Areas shall be worked out in sq mt correct to two places of decimal.
3. Cubical contents shall be worked out to the nearest 0.01 cum.

Parts of work required to be dismantled and those required to be demolished shall be measured separately.

Measurements of all works except hidden work shall be taken before demolition or dismantling and no allowance for increase in bulk shall be allowed.

Specifications for deduction for voids, openings etc. shall be on the same basis as that adopted for new construction of the work.

Work executed in the following conditions shall be measured separately:

1. Work in or under water and / or liquid mud;
2. Work in or under foul position.

2.4.3 Rates

The rate shall include the cost of all labour involved and tools used in demolishing and dismantling including scaffolding. The rate shall also include the charges for separating out and stacking the serviceable material properly and disposing off unserviceable material within a distance of 50 m.

The rate shall also include for temporary shoring for the safety of portions not required to be pulled down, or of adjoining property, and providing temporary enclosures or partitions, where considered necessary.

2.5 Roofs

Roof coverings generally including battens boarding, mats, bamboo jaffari or other subsidiary supports shall be measured in sq mt except lead sheet roof covering, which shall be measured in tonnes and stone slab roof covering which shall be measured in cum.

Ridges, hips and valleys shall be girthed and included with the roof area. Corrugated or semi corrugated surfaces shall be measured flat and not girthed.

Mud phuska on roofs shall be measured in cum.

Lead sheets in roofs shall be measured in tonnes and hips, valleys, flashings; lining to gutter etc. shall be included in this weight.

R.B. or R.C.C. roofs shall be measured in cum and if reinforcement is required to be salvaged, it shall be so stated. When reinforcement is required to be separated, scraped and cleaned, the work shall be measured separately as tonnes of salvaged steel.

Supporting members, such as rafters, purlins, beams joists, trusses etc. where of wood shall be measured in cum and steel or iron sections in tonnes.

2.6 Ceiling

The stripping of ceilings shall be measured in sqm.

Dismantling of supporting joists, beams, etc. shall be measured in cum or in tonnes.

Height above floor levels if it exceeds 3.5 m shall paid for separately.

2.7 Flooring and Paving

Dismantling of floors (except concrete and brick floors) shall be measured in sqm. Supports such as joints, beams etc. if any shall be measured as per Clause 2.5.6**.** Concrete and bricks paving shall be measured as per Clause 2.8.

2.8 Concrete and Brick Roofs and Suspended Floors

Demolition of floors and roofs of concrete or brick shall be measured in cum. Beams cantilevers or other subsidiary supports of similar materials shall be included in the item. In measuring thickness of roofs provided with water proofing treatments with bitumen, felts, the thickness of water proofing treatment shall be ignored.

2.9 Walls and Piers

Taking down walls and independent piers or columns of brick, stone or concrete shall be measured, in cum. All copings, corbels, cornices and other projections shall be included with the wall measurements.

In measuring thickness of plastered walls, the thickness of plaster shall be ignored.
Ashlar face stones, dressed stone work, precast concrete articles, etc. if required to be taken down intact shall be so stated, and measured separately in cum.

Cleaning bricks stacking for measurements including all extra handling and removal and disposing off the rubbish as stated shall be enumerated in thousand of cleaned bricks.

Cleaning stone obtained from demolished / dismantling stone masonry of any description including ashlar facing dressed stone work, stone slabs or flagging and precast concrete blocks including all extra handling and disposing of the rubbish as stated shall be measured in cum of cleaned stone.

Honey comb works or cavity walls of bricks stone or concrete shall be measured as solid.

2.10 Reinforced Concrete and Brick Work

Reinforced concrete structures and reinforced brick roof and walls shall be measured in cum and if reinforcement is required to be salvaged, it shall be so stated.

Where reinforcement is required to be separated, scraped and cleaned, the work shall be measured separately in tonnes of salvaged steel.

2.11 Partitions, Trellis Work, Etc.

Partitions or light walls of lath and plaster, trellis work, expanded metal, thin concrete or terracotta slabs and other similar materials including frame work if any shall be measured in sqm stating the over all thickness.

2.12 Wood Work

All wood work including carries average 40 sq cm or over in section, shall be measured in cum, while that under 40 sq cm in section, in running meters. Ballies shall be measured in running meters.
Boarding including wooden chajjas and sun shades along with supports shall be measured in square m in its plane.

2.13 Steel and Iron Work

All steel and iron work shall be measured in tonnes. The weight shall be computed from standard tables unless the actual weight can readily be determined.

Riveted work, where rivets are required to be cut, shall be measured separately.

Marking of structural steel required to be re-erected shall be measured separately.

In framed steel items, the weight or any covering material or filling such as iron sheets and expanded metal shall be included in the weight of the main article unless such covering is not ordered to be taken out separately.

2.14 Doors and Windows

Dismantling of doors, windows, clerestory windows, ventilators etc. (Wood or metal) whether done separately or along with removal of wall by making recess in the wall shall be enumerated. Those exceeding 3 sqm each in area shall be measured separately. The item shall include removal of chowkhats architraves, hold fasts and other attachments.

If only shutters are to be taken out it shall be measured separately.

2.15 Pipes and Sewer Lines

Water pipe lines including rain water pipes with clamps and specials, sewer lines (salt glazed ware or concrete) etc. shall be described by their diameter and length measured in running m inclusive of joints.

If the joints, special and fittings etc. are required to be separated, it shall be so stated and enumerated.

Pucca drains shall be measured under relevant items.

Value cistern, public fountain platform, fire hydrants, etc. shall be enumerated.

Manholes and inspection chambers shall be enumerated stating the size and depth of manhole/inspection chamber. They shall be classified into different groups depending upon the depth, in unit of half and one m depth. The depth of the manhole shall be the distance between the top of manhole cover and invert level of the drain.

Ventilating shafts, gully traps, flushing cisterns and other appurtenant items of work shall be enumerated.

2.16 Posts or Struts

Posts or struts (wood, steel or RCC) section including taking out embedded portion shall be measured in running m.

2.17 Fencing Wire Mesh

Wire mesh fencing of any type with frame shall be measured in square m.

2.18 Glazing

Taking out any portion of serviceable glass except polished plate, from old sashes, skylights, etc. (any thickness, weight or size) raking out old putty, etc. shall be measured in square m.

Irregular or circular panes shall be measured as rectangle or square enveloping the same, the width and height being measured correct to the nearest 0.5 cm.

2.19 Dismantling Culverts, Bridges and Other Structures/Pavements

2.19.1 Dismantling Culverts and Bridges

The structures shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the serviceable materials to be salvaged, the part of the structure to be retained and any other properties or structures nearby.

Unless otherwise specified, the superstructure portion of culverts / bridges shall be entirely removed and other parts removed below the ground level or as necessary depending upon the interference they cause to the new construction. Removal of overlaying or adjacent material, if required in connection with the dismantling of the structures shall be incidental to this item.
Where existing culvert / bridges are to be extended or otherwise incorporated in the new work, only such part or parts of the exiting structure shall be removed as are necessary and directed by the Engineer to provide a proper connection to the new work. The connecting edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging any part of the structure to be retained. Due care should be taken to ensure that reinforcing bars which are to be left in place to project into the new work as dowels or ties are not injured during removal of concrete.

Pipe culverts shall be carefully removed in such manner as to avoid damage to the pipes.

Steel structures shall, unless otherwise provided, be carefully dismantled in such a manner as to avoid damage to members thereof. If specified in the Drawings or directed by the Engineer that the structure is to be removed in a condition suitable for re-erection, all members shall be match-marked by the Contractor with white lead paint before dismantling; end pins, nuts, loose plates, etc., shall be similarly marked to indicate their proper location; all pins, pin holes and machined surfaces shall be painted with a mixture of white lead and tallow and all loose parts shall be securely wired to adjacent members or packed in boxes.

Timber structures shall be removed in such a manner as to avoid damage to such timber or lumber when designated by the Engineer to be salvaged.

2.19.2 Dismantling Pavements and Other Structures

In removing pavements, kerbs, gutters and other structures like guard-rails, fences, manholes, catch-basins, inlets, etc. where portions of the existing construction are to be left in the finished work, the same shall be removed to an existing joint or cut and chipped to a true line with a face perpendicular to the surface of the existing structure. Sufficient removal shall be made to provide for proper grades and connections with the new work as directed by the Engineer.

All concrete pavements, base courses in carriageway and shoulders etc., designated for removal shall broken to pieces whose volume shall not exceed 0.02 cum and stockpiled at designated locations if the material is to be used later or otherwise arranged for disposal as directed (see Clause 2.19.4).

2.19.3 Back-filling

Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and compacted to required density as directed by the Engineer.

2.19.4 Disposal of Materials

All materials obtained by dismantling shall be the property of Employer. Unless otherwise specified, materials having any salvage value shall be placed in neat stacks of like materials within the right-of-way, as directed by the Engineer with all lifts and up to a lead of 1000 m.

Pipe culverts that are removed shall be cleaned and neatly piled on the right-of-way at points designated by the Engineer with all lifts and lead up to 1000 m.

Structural steel removed from old structures shall, unless otherwise specified or directed, be stored in a neat and presentable manner on blocks in locations suitable for loading. Structures or portions thereof which are specified in the Contract for re-erection shall be stored in separate piles.

Timber or lumber from old structures which is designated by the Engineer as materials to be salvaged shall have all nails and bolts removed there from and shall be stored in neat piles in locations suitable for loading.

All materials obtained from dismantling operations which, in the opinion of the Engineer, cannot be used or auctioned shall be disposed of as directed by the Engineer with all lifts and up to a lead of 1000 m.

2.19.5 Measurements for Payment

The work of dismantling structures shall be paid for in units indicated below by taking measurements before and after, as applicable:

1.	Dismantling brick/stone masonry/concrete (plain and reinforced)	cum.
2.	Dismantling flexible and cement concrete pavement	cum.
3.	Dismantling steel structures	tonne
4.	Dismantling timber structures	cum.
5.	Dismantling pipes, guard rails, kerbs, gutters and fencing	linear m.
6.	Utility services	Nos.

2.19.6 Rates

The Contract unit rates for the various items of dismantling shall be paid in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment, safeguards and incidentals necessary to complete the work. These will also include excavation and backfilling where necessary to the required compaction and for handling, salvaging, piling and disposing of the dismantled materials within all lifts and up to a lead of 1000 m.

End of Section 2

SECTION 3

EARTHWORKS

SECTION 3

EARTHWORKS

3.1 Applicable Codes

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

a) IS 783 - 1985 - Code of practice for laying of concrete pipes.

b) IS 3764 - 1992 - Excavation work - Code of Safety.

c) IS 2720 - Methods of test for soils:

(Part-1) - 1983 - Preparation of dry soil samples for various tests.

(Part-2) - 1973 - Determination of Water Content.

(Part-4) - 1985 - Grain size analysis.

(Part-5) - 1985 - Determination of liquid and plastic limit.

(Part-7) - 1980 - Determination of water content - dry density relation using light compaction.

(Part-9) - 1992 - Determination of dry density - moisture content relation by constant weight of soil method.

(Part-14) - 1983- Determination of density index (relative density) of Cohesionless soils.

(Part-22) - 1972 - Determination of organic matter.

(Part-26) - 1987 - Determination of pH Value.

(Part-27) - 1987- Determination of total soluble sulphates.

(Part-28) - 1974- Determination of dry density of soils in place, by the sand replacement method.

(Part-33) -1971 - Determination of the density in place by the ring and water replacement method.

(Part-34) - 1972- Determination of density of soil in place by rubber baloon method.

(Part-38) - 1976- Compaction control test (Hilf Method).

3.2 Drawings

Engineer will furnish drawings wherever, in his opinion, such drawings are required to show areas to be excavated/filled grade level, sequence of priorities etc. Contractor shall follow strictly such drawings.

3.3 General

The Contractor shall furnish all tools, plant, instruments, qualified supervisory personnel, labour, materials, any temporary works, consumables, any and everything necessary, whether or not such items are specifically stated herein for completion of the work in accordance with the Specifications.

The Contractor shall survey the site before excavation and set out all lines and establish levels for various works such as grading, basement, foundations, plinth filling, roads, drains, cable trenches, pipelines etc. Such survey shall be carried out by taking accurate cross sections of the area perpendicular to established reference/grid lines at 8m intervals or nearer, if necessary, based on ground profile and thereafter properly recorded.

The excavation shall be carried out to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and also the furnishing, erecting and maintaining of substantial barricades around excavated areas and warning lamps at night.

The rates quoted shall also include for dumping of excavated material in regular heaps, bunds, riprap with regular slopes within the lead specified and levelling the same so as to provide natural drainage. Rock/soil excavated shall be stacked properly as approved by the Engineer. As a rule, all softer material shall be laid along the center of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Rock shall be stacked separately.

Topsoil shall be stock piled separately for later re-use.

3.4 Clearing

The area to be excavated/filled shall be cleared of fences, trees, plants, logs, stumps, bush, vegetation, rubbish, slush, etc. and other objectionable matter. If any roots or stumps of trees are encountered during excavation, they shall also be removed. The material so removed shall be disposed off as approved by the Engineer. Where earth fill is intended, the area shall be stripped of all loose/ soft patches, top soil containing objectionable matter/ materials before fill commences.

3.5 Classification

All materials to be excavated shall be classified by Engineer, into one of the following classes and shall be paid for at the rate tendered for that particular class of material. No distinction shall be made whether the material is dry, moist or wet. The decision of Engineer regarding the classification of the material shall be final and binding on Contractor and not be a subject matter of any appeal or arbitration.

Any earthwork will be classified under any of the following categories:

a) Ordinary & Hard Soils

These shall include all kinds of soils containing kankar, sand, silt, moorum and/or shingle, gravel, clay, loam, peat, ash, shale, etc., which can generally be excavated by spade, pick axes and shovel,

and which is not classified under "soft and decomposed rock" and "hard rock" defined below. This shall also include embedded rock boulders not longer than 1 metre in any one direction and not more than 200 mm in any one of the other two directions.

b) Soft and Decomposed Rock

This shall include rock, boulders, slag, chalk, slate, hard mica schist, laterite, highly weathered granite gneiss and all other materials which in the opinion of Engineer is rock, but does not need blasting and could be removed readily with picks, hammer, crow bars, wedges, and pneumatic breaking equipment. The mere fact that Contractor resorts to blasting for reasons of his own, shall not qualify for classification under "hard rock".

This shall also include excavation in macadam and tarred roads and pavements. This shall also include rock boulders not longer than 1 metre in any direction and not more than 500 mm in any one of the other two directions. Masonry to be dismantled will also be measured under this item.

c) Hard Rock

This shall include all rock occurring in large continuous masses which cannot be removed except by blasting, chiselling or by drilling with heavy mechanical breakers. Harder varieties of rock with or without veins and secondary minerals which, in the opinion of Engineer require blasting shall be considered as hard rock. Boulders of rock occurring in such sizes and not classified under (a) and (b) above shall also be classified as hard rock. Concrete work both reinforced and unreinforced to be dismantled will be measured under this item, unless a separate provision is made in the Schedule of Quantities.

Before classification of material as rock the Contractor shall demonstrate to the satisfaction of the Employer's Representative his inability to excavate it without resort to heavy percussion tools complete with rock bits, hydraulic wedges or blasting. Excavation by the use of explosive will not normally be permitted.

Material shall not be classified as rock unless the Employer's Representative has agreed to such classification on the basis of such a demonstration before its excavation. Excavations where rock has been encountered and classified as such shall not be backfilled before examination of the excavated faces by the Employer's Representative to enable the extent of the rock excavation to be determined.

3.6 Excavation

All excavation work shall be carried out by mechanical equipment unless, in the opinion of Engineer, the work involved requires it to be carried out by manual methods.

Excavation for permanent work shall be taken out to such widths, lengths, depths and profiles as are shown on the drawings provided by the Contractor or such other lines and grades as may be agreed with the Engineer. Rough excavation shall be carried out to a depth of 150mm above the final level. The balance shall be excavated with special care. Soft pockets shall be removed below the final level and extra excavation filled up with lean concrete of grade M10 with 40 mm downgraded aggregates as approved by the Engineer. The final excavation should be carried out just prior to laying the blinding course.

Contractor may, for facility of work or similar other reasons excavate, and also backfill later, if so approved by Engineer, at his own cost outside the lines shown on the drawings or directed by Engineer. Should any excavation be taken below the specified elevations, Contractor shall fill it up,

with concrete of the same class as in the foundation resting thereon, upto the required elevation. No extra shall be claimed by Contractor on this account.

All excavations shall be to the minimum dimensions required for safety and ease of working. Prior approval of the Engineer shall be obtained by the Contractor in each individual case, for the method proposed for the excavation, including dimensions, side slopes, dewatering, disposal, etc. This approval shall not in any way relieve the Contractor of his responsibility for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. Side slopes shall be as steep as will stand safely for the actual soil conditions encountered. Every precaution shall be taken to prevent slips. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid for if the slips are due to the negligence of Contractor.

3.7 Stripping Loose Rock

All loose boulders, detached rocks partially and other loose material which might move therewith not directly in the excavation but so close to the area to be excavated as to be liable, in the opinion of Engineer, to fall or otherwise endanger the workmen, equipment, or the work shall be stripped off and removed from the area of the excavation. The method used shall be such as not to render unstable or unsafe the portion which was originally sound and safe.

Any material not requiring removal in order to complete the permanent works, but which, in the opinion of Engineer, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed. The cost of such stripping will be paid for at the unit rates accepted for the class of materials in question.

3.8 Excavation in Hard Rock

3.8.1 General Requirements

Unless otherwise stated herein, BIS Specification "IS- 4081(1986) Safety code for Blasting and related Drilling Operations" shall be followed. After removal of overburden, if any, excavation shall be continued in rock to such widths, lengths, depths and profiles as are shown on the drawings or such other lines and grades as may be specified by the Engineer. As far as possible all blasting shall be completed prior to commencement of construction. At all stages of excavation, precautions shall be taken to preserve the rock below and beyond the lines specified for the excavation, in the soundest possible condition. The quantity and strength of explosive used shall be such as will neither damage nor crack the rock outside the limits of excavation. All precautions, as directed by the Engineer, shall be taken during the blasting operations and care shall be taken that no damage is caused to adjoining buildings or structure as a result of blasting operations. In case of damage to permanent or temporary structures, Contractor shall repair the same to the satisfaction of the Engineer at his cost. As excavation approaches its final lines and levels, the depth of the charge holes and amount of explosives used shall be progressively and suitably reduced.

Specific permission of the Engineer will have to be taken by Contractor for blasting rock and he shall also obtain a valid Blasting License from the authorities concerned. If permission for blasting is refused by the Engineer, the rock shall be removed by wedging, pick, barring, heating and quenching or other approved means. All loose or loosened rock in the sides shall be removed by barring, wedging, etc. The unit rate for excavation in hard rock shall include the cost of all these operations.

Contractor shall obtain necessary licence for storage of explosives, fuses and detonators issued to him from Employer's stores or from supplier arranged by him, from the authorities dealing with

explosives. The fees, if any, required for obtaining such license, shall be borne by Contractor. Contractor shall have to make necessary storage facilities for the explosives etc. as per rules of local, State and Central Government authorities and Statutory bodies/regulations. Explosives shall be kept dry and shall not be exposed to direct rays of sun or be stored in the vicinity of fire, stoves, steam pipes or heated metal, etc. No explosive shall be brought near the work in excess of quantity required for a particular amount of firing to be done; and surplus left after filling the holes shall be removed to the magazine. The magazine shall be built as for as possible away from the area to be blasted, Engineer's prior approval shall be taken for the location proposed for the magazine.

In no case shall blasting be allowed closer than 30 metres to any structure or to locations where concrete has just been placed. In the latter case the concrete must be at least 7 days old.

In the case of water transmission, pipe lines works etc for water transfer, the following stipulations shall over-ride the corresponding stipulations in "General Requirements" given above:

Excavation in hard rock shall be only by chiseling / Jack hammering or by drilling with mechanical brakers.

The rock shall be removed by wedging, pick, boring, heating and quenching or other approved non-blasting methods. All loose or loosened rock in the sides shall be removed by barring, wedging etc. The unit rate for excavation in hard rock shall include the cost of all these operations. No blasting is allowed.

3.8.2 Specific Requirements

For blasting operations, the following points shall be observed.

Contractor shall employ a competent and experienced supervisor and licensed blaster in-charge of each set of operation, who shall be held personally responsible to ensure that all safety regulations are carried out.

Before any blasting is carried out, Contractor shall intimate Engineer and obtain his approval in writing for resorting to such operations. He shall intimate the hours of firing charges, the nature of explosive to be used and the precautions taken for ensuring safety.

Contractor shall ensure that all workmen and the personnel at site are excluded from a area within 200 m. radius from the firing point, at least 5 minutes before firing time by sounding warning whistle. The area shall also be given warning by sounding a distinguishing whistle.

The blasting of rock near any existing buildings, equipment or any other property shall be done under cover if permitted by the Engineer and Contractor has to make all such necessary muffling arrangements. Covering may preferably be done by M.S. plates with adequate dead weight over them.

Blasting shall be done with small charges only and where directed by Engineer, a trench shall have to be cut by chiseling prior to the blasting operation separating the area under blasting from the existing structures.

The firing shall be supervised by a Supervisor and not more than 6 (six) holes at a time shall be set off successively. If the blasts do not tally with the number fired, the misfired holes shall be carefully located after half an hour and when located, shall be exploded by drilling a fresh hole along the misfired hole (but not nearer than 600 mm from it) and by exploding a new charge.

A wooden tamping rod with a flat end shall be used to push cartridges home and metal rod or hammer shall not be permitted. The charges shall be placed firmly into place and not rammed or pounded. After a hole is filled to the required depth, the balance of the hole shall be filled with stemming which may consist of sand or stone dust or similar inert material.

Contractor shall preferably detonate the explosives electrically.

The explosives shall be exploded by means of a primer which shall be fired by detonating a fuse instantaneous detonator (F.I.D) or other approved cables. The detonators with F.I.D shall be connected by special nippers.

In dry weather and normal dry excavation, ordinary low explosive gunpowder may be used. In damp rock, high explosive like gelatine with detonator and fuse wire may be used. Under water or for excavation in rock with substantial accumulated seepage electric detonation shall be used.Holes for charging explosive shall be drilled with pneumatic drills, the drilling pattern being so planned that rock pieces after blasting will be suitable for handling without secondary blasting.

When excavation has almost reached the desired level, hand trimming shall have to be done for dressing the surface to the desired level. Any rock excavation beyond an overbreak limit of 75 mm shall be filled up as instructed by Engineer, with concrete of strength not less than M100. The cost of filling such excess depth shall be borne by Contractor and the excavation carried out beyond the limit specified above will not be paid for. Stopping in rock excavation shall be done by hand trimming.

Contractor shall be responsible for any accident to workmen, public or Employer's property due to blasting operations. Contractor shall also be responsible for strict observance of rules, laid by Inspector of Explosives, or any other Authority duly constituted under the State and /or Union Government.

3.9 Fill, Backfilling and Site Grading

3.9.1 General

All fill material shall be subject to the Engineer‟s approval. If any material is rejected by Engineer, the Contractor shall remove the same forthwith from the site. Surplus fill material shall be deposited/disposed off as directed by Engineer after the fill work is completed.

No earthfill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with to the approval of the Engineer.

The Contractor shall not commence the placement of any fill or backfill at any location without the approval of the Engineer.

3.9.2 Material

To the extent available, selected surplus soils from excavations shall be used as backfill. Backfill material shall be free from lumps, organic or other foreign material. All lumps of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of murum or earth to fill the voids and the mixture used for filling.

If fill material is required to be imported, the Contractor shall make arrangements to bring such material from outside borrow pits. The material and source shall be subject to the prior approval of the Engineer. The approved borrow pit areas shall be cleared of all bushes, roots of trees, plants, rubbish, etc. Top soil containing foreign material shall be removed. The materials so removed shall

be disposed off as directed by Engineer. The Contractor shall provide the necessary access roads to borrow areas and maintain the same if such roads do not exist, at his cost.

3.9.3 Filling in pits and trenches around foundations of structures, walls, etc.

As soon as the work in foundations has been accepted and measured, the spaces around the foundations, structures, pits, trenches, etc., shall be cleared of all debris and filled with earth in layers not exceeding 15 cm, each layer being watered, rammed and properly consolidated, before the succeeding one is laid. Each layer shall be consolidated to the satisfaction of Engineer. Earth shall be rammed with approved mechanical compaction machines. Usually no manual compaction shall be allowed unless the Engineer is satisfied that in some cases manual compaction by tampers cannot be avoided. The final backfill surface shall be trimmed and leveled to a proper profile to the approval of the Engineer.

3.9.4 Plinth Filling

Plinth filling shall be carried out with approved material as described hereinbefore in layers not exceeding 15cm, watered and compacted with mechanical compaction machines. The Engineer may, however, permit manual compaction by hand tampers where he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlement at a later stage. The finished level of the filling shall be trimmed to the level/slope specified.

Compaction of the plinth fill shall be carried out by means of 12 ton rollers smooth wheeled, sheep-foot or wobbly wheeled rollers. In case of compaction of granular material such as sands and gravel, vibratory rollers shall be used. A smaller weight roller may be used only if permitted by the Engineer. As rolling proceeds, water sprinkling shall be done to assist consolidation. Water shall not be sprinkled in case of sandy fills.

The thickness of each unconsolidated fill layer can in this case be upto a maximum of 300mm. The Contractor will determine the thickness of the layers in which fill has to be consolidated depending on the fill material and equipment used and the approval of the Engineer obtained prior to commencing filling.

Rolling shall commence from the outer edge and progress towards the centre and continue until compaction is to the satisfaction of Engineer, but in no case less than 10 passes of the roller will be accepted for each layer.

The compacted surface shall be properly shaped, trimmed and consolidated to an even and uniform gradient. All soft spots shall be excavated, then filled and consolidated.

At some locations/areas, it may not be possible to use rollers because of space restrictions, etc. The Contractor shall then be permitted to use pneumatic tampers, rammers, etc. and he shall ensure proper compaction.

3.9.5 Sand Filling in Plinth and Other Places

Where backfilling is required to be carried out with local sand it shall be clean, medium grained and free from impurities. The filled-in-sand shall be kept flooded with water for 24 hours to ensure maximum consolidation. Any temporary work required to contain sand under flooded condition shall be on Contractor's account. The surface of the consolidated sand shall be dressed to required level or

slope. Construction of floors or other structures on sand fill shall not be started until the Engineer has inspected and approved the fill.

3.9.6 Filling in Trenches

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed. The backfilling material shall be properly consolidated by watering and ramming, taking due care that no damage is caused to the pipes.

Where the trenches are excavated in soil, the filling from the bottom of the trench to the level of the centre line of the pipe shall be done by hand compaction with selected approved earth in layers not exceeding 8 cm; backfilling above the level of the centre line of the pipes shall be done with selected earth by hand compaction, or other approved means in layers not exceeding 15 cm.

In case of excavation of trenches in rock, the filling upto a level 30 cm above the top of the pipe shall be done with fine materials such as earth, murum, etc. The filling up to the level of the centre line of the pipe shall be done by hand compaction in layers not exceeding 8 cm whereas the filling above the centre line of the pipe shall be done by hand compaction or approved means in layers not exceeding 15 cm. The filling from a level 30 cm above the top of the pipe to the top of the trench shall be done by hand or other approved mechanical methods with broken rock filling of size not exceeding 15 cm mixed with fine material as available to fill up the voids.

Filling of the trenches shall be carried out simultaneously on both sides of the pipe to avoid unequal pressure on the pipe.

In the case of water transmission, pipe lines works etc for water transfer, the Contractor shall take proper precautions against the risks of floatation. Should any section of the pipeline be affected by floatation in the course of works the entire work shall be removed and then reinstalled to the satisfaction of Engineer.

3.10 General Site Grading

Site grading shall be carried out as indicated in the drawings and as approved by the Engineer. Excavation shall be carried out as specified in the Specifications. Filling and compaction shall be carried out as specified under Clause 3.9 and elsewhere unless otherwise indicated below.

The fill has to be compacted in layers not exceeding 225 mm and levelled uniformly and compacted as indicated in Clause 3.9 before the next layer is deposited.

To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the Contractor at his cost.

Field compaction tests shall be carried out in each layer of filling until the fill to the entire height has been completed. This shall hold good for embankments as well. The fill will be considered as incomplete if the desired compaction has not been obtained.

The Contractor shall protect the earth fill from being washed away by rain or damaged in any other way. Should any slip occur, the Contractor shall remove the affected material and make good the slip at his cost.

If so specified, the rock as obtained from excavation may be used for filling and leveling to indicated grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cms approximately. After rock filling to the approximate level, indicated above has been carried out,

the void in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and earth shall be laid and consolidation carried out by a 12 ton roller. No less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up.

3.11 Fill Density

The compaction, where so called for, shall comply with minimum 95% Modified Proctor density at moisture content differing not more than 4% from the optimum moisture content. The Contractor shall demonstrate adequately by field and laboratory tests that the specified density has been obtained.

3.12 Lead

Lead for deposition/disposal of excavated material, shall be as specified in the respective item of work. No extra compensation is admissible on the grounds that the lead including that for borrowed material had to be transported over marshy or "katcha' land/route.

3.13 Measurement and Payment

All excavation shall be measured nett. Dimensions for purpose of payment shall be reckoned on the horizontal area of the excavation at the base for foundations of the walls, columns, footings, tanks, rafts or other foundations/structures to be built, multiplied by the mean depth from the surface of the ground in accordance with the drawings. Excavations in side slopes will not be paid for. Contractor may make such allowance in his rates to provide for excavation in side slopes keeping in mind the nature of the soil and safety or excavation. Reasonable working space, beyond concrete dimensions and shuttering where considered necessary in the opinion of Engineer will be allowed in excavation and considered for payment. However, if concreting is proposed against the excavated sides, no such over-excavation will be permitted. In such cases over-excavation shall be made good by Contractor with concrete of the same class as in the foundations at his cost.

In the case of water transmission, pipe lines works etc for water transfer trench excavation shall be measured using the dimensions detailed in the standard section shown on the Drawings. No payment will be made for working space except where clearly mentioned on the drawings. Excavation beyond the widths or depths required will not be paid for any additional concrete or bedding material required as a result of over-excavation at the Contractor's expense.

Backfilling as per specification the sides of foundations of columns, footings, structures, walls, tanks, rafts, trenches etc. with excavated material will not be paid for separately. It shall be clearly understood that the rate quoted for excavation including backfilling shall include stacking of excavated material as directed, excavation/packing of selected stacked material, conveying it to the place of final backfill, compaction etc. as specified. As a rule material to be backfilled shall be stacked temporarily within the basic lead of 100 metres unless otherwise directed by the Engineer. If Engineer directs/permits a lead of over 100 metres for such material, the conveyance of the material for the extra distance over the basic lead of 100 metres for backfilling will be paid for.

Payment for fill inside trenches, plinth or similar filling with selected excavated material will be made for only compaction as specified/directed. Cost of all other operations shall be deemed to have been covered in the rate quoted for excavation. Payment for this work will be made based on measurement of plinth/trench dimensions as per drawings. The plinth ground levels shall be surveyed

before hand for this purpose. If no compaction is specified/desired such filling will not be separately paid for. In such an event the fill shall be leveled/finished to the profile as directed at no extra cost.

Backfilling, plinth filling etc. with borrowed earth will be paid for at rates quoted. The quoted rate shall include all operations such as clearing, excavation, lead and transport, fill, compaction etc, as specified. Actual quantity of consolidated filling or actual quantity or excavation in the borrow pits (less such top soil which has been excavated and not used for filling) whichever is less shall be measured and paid for in cubic metres. The lead, lift etc. shall be as indicated in the schedule of quantities.

Actual quantity of consolidated sand filling shall be measured and paid in cubic metres.

Volume of rock excavated shall be calculated on the basis of length, breadth and depth of excavation indicated on the drawings. No payment will be made for excavations/overbreak beyond payment line specified. Where such measurement is not possible as in the case of strata intermixed with soil, excavated rock shall be properly stacked as directed by Engineer and the volume of rock calculated on the basis of stack measurements after making appropriate allowance for voids. The allowance to be made for voids shall be decided by Engineer and this will not be a subject matter of dispute or appeal.

3.14 Timber Shoring

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'polling boards'. These shall be of minimum 25 cm x 4 cm sections or as approved by the Engineer. The boards shall generally be placed in position vertically side by side without any gap on each side of the excavation and shall be secured by horizontal walings of strong wood at maximum 1.2 metre spacings, strutted with ballies or as approved by the Engineer. The length of the ballie struts shall depend on the width of the trench or pit. If the soil is very soft and loose, the boards shall be placed horizontally against each side of the excavation and supported by vertical walings, which in turn shall be suitably strutted. The lowest boards supporting the sides shall be taken into the ground and no portion of the vertical side of the trench or pit shall remain exposed, so as to render the earth liable to slip out.

Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit or trench. The type of timbering shall be as approved by the Engineer. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of excavations, trenches, pits, etc. from collapsing.

Timber shoring may also be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only under instructions from the Engineer.

The withdrawal of the timber shall be done carefully to prevent the collapse of the pit or trench. It shall be started at one end and proceeded with, systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber.

In the case of open timbering, the entire surface of the side of trench or pit is not required to be covered. The vertical boards of minimum 25 cm x 4 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangement, sizes of the

timber and the spacings shall be subject to the approval of the Engineer. In all other respects, the Specifications for close timbering shall apply to open timbering.

In case of large pits and open excavations, where shoring is required for securing safety of adjoining structures or for any other reasons and where the planking across sides of excavations/pits cannot be strutted against, suitable inclined struts supported on the excavated bed shall be provided. The load from such struts shall be suitably distributed on the bed to ensure no yielding of the strut. If however,

Engineer directs any timbering to be left-in, keeping in mind the type of construction or any other factor, Contractor shall be paid for at the scheduled item rate for such left-in timbering.

3.15 Measurement

Unless separately provided for in the Schedule of Quantities, the actual effective area of shored faces as approved by Engineer shall be measured in sq.m. The area of planking embedded in the bed/sides of excavation will not be considered, nor the area supporting inclined struts in case of large pits/open excavation. All planks, boards, walings, verticals, struts, props and all other materials required for shoring and subsequent safe dismantling and removal shall be included in the quoted unit rates.

3.16 D`ewatering

The Contractor shall ensure that the excavation and the structures are free from water during construction and shall take all necessary precautions and measures to exclude ground/rain water so as to enable the works to be carried out in reasonably dry conditions in accordance with the construction programme. Sumps made for dewatering must be kept clear of the excavations/trenches required for further work. The method of pumping shall be approved by Engineer, but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction. The dewatering shall be continued for at least (7) seven days after the last pour of the concrete. The Contractor shall, however, ensure that no damage to the structure results on stopping of dewatering.

The Contractor shall study the sub-soil conditions carefully and shall conduct any tests necessary at the site with the approval of the Engineer to test the permeability and drainage conditions of the sub-soil for excavation, concreting etc., below ground level.

The scheme for dewatering and disposal of water shall be approved by the Engineer. The Contractor shall suitably divert the water obtained from dewatering from such areas of site where a build up of water in the opinion of the Engineer obstructs the progress of the work, leads to insanitary conditions by stagnation, retards the speed of construction and is detrimental to the safety of men, materials, structures and equipment.

When there is a continuous inflow of water and the quantum of water to be handled is considered in the opinion of Engineer, to be large, a well point system- single stage or multistage, shall be adopted. The Contractor shall submit to the Engineer, details of his well point system including the stages, the spacing, number and diameter of well points, headers etc., and the number, capacity and location of pumps for approval. Unless separately provided for in the Schedule of prices, the cost of dewatering shall be included in the item rate for excavation.

3.17 Measurement

Unless separately provided for in the Schedule of quantities, dewatering is deemed to have been included in the unit rates quoted for excavation. If separately provided for, the unit of measurement shall be as indicated in the Schedule of Quantities.

3.18 Rain Water Drainage

Grading in the vicinity of excavation shall be such as to exclude rain/ surface water draining into excavated areas. Excavation shall be kept clean of rain and such water as the Contractor may be using for his work by suitably pumping out the same. The scheme for pumping and discharge of such water shall be approved by the Engineer.

3.19 Earthen Embankment Construction

3.19.1 Scope

These Specifications shall apply to the construction of embankments including sub grades, earthen shoulders and miscellaneous backfills with approved materials obtained from roadway and drain excavation, borrow pits or other sources. All embankments, subgrade, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades, and cross-sections shown on the Drawings or as directed by the Engineer.

3.19.2 Physical Requirements of materials

The materials used in embankments, sub grades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, a mixture of those or any other material approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment/subgrade.

The following types of material shall be considered unsuitable for

embankment: Materials from swamps, marshes and bogs;

Peat, log, stump and perishable material; any soil that classifies as OL, OI, OH or Pt in accordance with IS: 1498.

Materials susceptible to spontaneous combustion;

Materials in a frozen conditions;

Clay having liquid limit exceeding 70 and plasticity index exceeding 45; and

Materials with salts resulting in leaching in the embankment.

Expansive clay exhibiting marked swell and shrinkage properties ("free swelling index" exceeding 50 percent when tested as per IS: 2720 Part 40) shall not be used as a fill material. Where expansive clay with acceptable "free swelling index" value is used as a fill material, subgrade and top 500 mm portion of the embankment just below subgrade shall be non-expansive in nature.

Any fill material with a soluble sulphate content exceeding 1.9 grams of sulphate (expressed as SO3) per litre when tested in accordance with BS: 1377 Test 10, but using a 2:1 water-soil ratio shall not

be deposited within 500 mm or other distance described in the Contract, of concrete, cement bound materials or other cementitious materials forming part of the Permanent Works.

Materials with a total sulphate content (expressed as SO3) exceeding 0.5 percent by mass, when tested in accordance with BS: 1377 Test 9 shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent Works.

The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when being placed in the embankment and 50 mm when placed in the subgrade. However, the Engineer may at his discretion permit the use of material coarser than this also if he is satisfied that the same will not present any difficulty as regards the placement of fill material and its compaction to the requirements of these Specifications. The maximum particle size shall not be more than two-thirds of the compacted layer thickness.

Ordinarily, only the materials satisfying the density requirements given in Table 5-3 shall be employed for the construction of the embankment and the subgrade.

Table-I. Density Requirements of Embankment and Subgrade Materials

Sr.	Type of Work	Maximum laboratory dry unit weight when tested as per IS: 2720 (Part 8)
1.	Embankments up to 3 metres height, not subjected to extensive flooding.	Not less than 15.2 kN/cum.
2.	Embankments exceeding 3 metres height or embankments of any height subject to long periods of inundation	Not less than 16.0 kN/cum.
3.	Sub grades and earthen shoulders / verges / backfill	Not less than 17.5 kN/cum.

Notes:

This Table is not applicable for lightweight fill material e.g. cinder, fly ash etc.

The Engineer may relax these requirements at his discretion taking into account the availability of materials for construction and other relevant factors.

The material to be used in subgrade should also satisfy design CBR at the dry unit weight applicable as per Table-II.

3.19.3 General requirements of materials

The materials for embankment shall be obtained from approved sources with preference given to materials becoming available from nearby roadway excavation or any other excavation under the same Contract.

The work shall be so planned and executed that the best available materials are saved for the subgrade and the embankment portion just below the subgrade.

3.19.3.1 Borrow Materials

Where the materials are to be obtained from designated borrow areas, the location, size and shape of these areas shall be as indicated by the Engineer and the same shall not be opened without his written permission. Where specific borrow areas are not designated by the Employer / the Engineer, arrangement for locating the source of supply of material for embankment and subgrade as well as compliance to environmental requirements in respect of excavation and borrow areas as stipulated, from time to time by the Ministry of Environment and Forests, Government of India and the local bodies, as applicable, shall be the sole responsibility of the Contractor.

Borrow pits along the road shall be discouraged. If permitted by the Engineer, these shall not be dug continuously. Ridges of not less than 8 m width should be left at intervals not exceeding 300 m. Small drains shall be cut through the ridges to facilitate drainage. The depth of the pits shall be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of the bank, the maximum depth in any case being limited to 1.5 m. Also, no pit shall be dug within the offset width from the toe of the embankment required as per the consideration of stability with a minimum width of 10 m.

Haulage of material to embankments or other areas of fill shall proceed only when sufficient spreading and compaction plants is operating at the place of deposition.

No excavated acceptable material other than surplus to requirements of the Contract shall be removed from the site. Should the Contractor be permitted to remove acceptable material from the site to suit his operational procedure, then he shall make good any consequent deficit of material arising there from.

Where the excavation reveals a combination of acceptable and unacceptable materials, the Contractor shall, unless otherwise agreed by the Engineer, carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the permanent works without contamination by the unacceptable materials. The acceptable materials shall be stockpiled separately.

The Contractor shall ensure that he does not adversely affect the stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

The Contractor shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing programme approved by the Engineer. It shall be ensured that the subgrade material when compacted to the density requirements as in Table II shall yield the design CBR value of the subgrade.

Table-II . Compaction Requirements for Embankment and Subgrade

Sr	Type of work/ material	Relative compaction as percentage of max. laboratory dry density as per IS: 2720 (Part 8)
1.	Subgrade and earthen shoulders	Not less than 97
2.	Embankment	Not less than 95
3.	Expansive Clays	
	a) Subgrade and 500 mm portion just below the subgrade	Not allowed
	b) Remaining portion of embankment	Not less than 90

The Contractor shall at least 7 working days before commencement of compaction submit the following to the Engineer for approval:

The values of maximum dry density and optimum moisture content obtained in accordance with IS: 2720 (Part 7) or (Part 8), as the case may be, appropriate for each of the fill materials he intends to use.

A graph of density plotted against moisture content from which each of the values in (1) above of maximum dry density and optimum moisture content were determined.

The Dry density-moisture content-CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part 7), heavy corresponding to IS: 2720 (Part 8) and intermediate in-between the two) for each of the fill materials he intends to use in the subgrade.

Once the above information has been approved by the Engineer, it shall from the basis for

compaction.

3.19.4 Construction Operations for Embankments

3.19.4.1 Setting out

After the site has been cleared to Section-1, the work shall be set out. The limits of embankment/subgrade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment / subgrade shall be built sufficiently wider than the design dimension so that surplus materials may be trimmed, ensuring that the remaining material is to the desired density and in position specified and conforms to the specified side slopes.

3.19.4.2 Dewatering

If the foundation of the embankment is in an area with stagnant water, and in the opinion of the Engineer it is feasible to remove it, the same shall be removed by bailing out or pumping, as directed by the Engineer and the area of the embankment foundation shall be kept dry. Care shall be taken to discharge the drained water so as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole responsibility of the Contractor to repair / restore it to original condition or compensate the damage at his own cost. If the embankment is to be constructed under Water, Clause 3.19.5 shall apply.

3.19.4.3 Stripping and Storing topsoil

In localities where most of the available embankment materials are not conducive to plant growth, or when so directed by the Engineer, the topsoil from all areas of cutting and from all areas to be covered by embankment foundation shall be stripped to specified depths not exceeding 150 mm and stored in stockpiles of height not exceeding 2 m for covering embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired. Topsoil shall not be unnecessarily trafficked either before stripping or when in a stockpile. Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum.

3.19.4.4 Compacting ground supporting Embankment / Subgrade

When necessary, the original ground shall be leveled to facilitate placement of first layer of embankment, scarified, mixed with water and then compacted by rolling so as to achieve minimum dry density as given in Table-II.

In case where the difference between the subgrade level (top of the subgrade on which pavement rests) and ground level is less than 0.5 m and the ground does not have 97 percent relative compaction with respect to the dry density as given in Table 5-4, the ground shall be loosened up to a level 0.5 m below the subgrade level, watered and compacted in layers in accordance with Clause 3.19.4 to not less than 97 percent of dry density as given in Table-II.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation shall be removed and replaced by approved materials laid in layers to the required degree of compaction.

Embankment or subgrade work shall not proceed until the foundations of embankments/subgrade have been inspected by the Engineer for satisfactory condition and approved.

Any foundation treatment specified for embankments especially high embankments, resting on suspect foundations as revealed buy borehole logs shall be carried our in a manner and to the depth as desired by the Engineer. Where the ground on which and embankment is to be built has any of the material types specified in Clause 3.19.2, at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

3.19.4.5 Spreading material in layers and bringing to appropriate moisture content

The embankment and subgrade material shall be spread in layers of uniform thickness not exceeding 200 mm compacted thickness over the entire width of embankment by mechanical means, finished by a motor grader and compacted as per Clause 3.19.4. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the specific slope and grade. Successive layers shall not be placed until the layer under construction has been thoroughly compacted to the specified requirements as in Table-II and got approved by the Engineer. Each compacted layer shall be finished parallel to the final cross-section of the embankment.

Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of agreed limits, the same shall be made good. Where water is required to be added in such construction, water shall be sprinkled from a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to variable widths of surfaces but without any flooding. The water shall be added uniformly and thoroughly mixed in soil by blading, discing or harrowing until and uniform moisture content is obtained throughout the depth of the layer.

If the; material delivered to the roadbed is too wet, it shall be dried, by aeration and exposure to the sun, till the; moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, compaction work shall be suspended.

Moisture content of each layer of soil shall be checked in accordance with IS: 2720 (Part 2), and unless otherwise mentioned, shall be so adjusted, making due allowance for evaporation losses, that

at the time of compaction it is in the range of 1% above to 2% below the optimum moisture content determined in accordance with IS: 2720 (Part 7) or IS: 2720 (Part 8) as the case may be. Expansive clays shall, however, be compacted at moisture content corresponding to the specified dry density, but on the wet side of the optimum moisture content obtained from the laboratory compaction curve.

After adding the required amount of water, the soil shall be processed by means of graders, harrows, rotary mixers or as otherwise approved by the Engineer unit the layer is uniformly wet.

Clods or hard lumps of earth shall be broken to have a maximum size of 75 mm when being placed in the embankment and a maximum size of 50 mm when being placed in the subgrade.

Embankment and other areas of fill shall, unless otherwise required in the Contract or permitted by the Engineer, be constructed evenly over their full width and their fullest possible extent and the Contractor shall control and direct construction plant and other vehicular traffic uniformly over them. Damage by construction plant and other vehicular traffic shall be made good by the Contractor with material having the same characteristics and strength as the material had before it was damaged.

Embankments and other areas of unsupported fills shall not be constructed with steeper side slopes, or to greater widths than those shown in the Contract, except to permit adequate compaction at the edges before trimming back, or to obtain the final profile following any settlement of the fill and the underlying material.

Whenever fill is to be deposited against the face of a natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical on 4 horizontal, such faces shall be benched as per Clause 3.19.5 immediately before placing the subsequent fill.

All permanent faces of side slopes of embankments and other areas of fill formed shall, subsequent to any trimming operations, be reworked and sealed to the satisfaction of the Engineer by tracking a tracked vehicle, considered suitable by the Engineer, on the slope or any other method approved by the Engineer.

3.19.4.6 Compaction

Only the compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during construction. Smooth wheeled, vibratory, pneumatic tyred, sheep foot or pad foot rollers, etc., of suitable size and capacity as approved by the Engineer shall be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

The compaction shall be done with the help of vibratory roller of 80 to 100 kN static weight with plain or pad foot drum or heavy pneumatic tyred roller of adequate capacity capable of achieving required compaction.

The Contractor shall demonstrate the efficiency of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for these site trials shall first be submitted to the Engineer for approval.

Earthmoving plant shall not be accepted as compaction equipment nor shall the use of a lighter category of plant to provide any preliminary compaction to assist the use of heavier plant be taken into account.

Each layer of the material shall be thoroughly compacted to the densities specified in Table 5-4. Subsequent layers shall be placed only after the finished layer has been tested according to Clause 903.2.2 of MoST Specifications for Roads and Bridge Works (IV Revision) and accepted by the Engineer. The Engineer may permit measurement of field dry density by a nuclear moisture / density gauge used in accordance with agreed procedure and the gauge is calibrated to provide results identified to that obtained from tests in accordance with IS: 2720 (Part 28). A record of the same shall be maintained by the Contractor.

When density measurement reveal any soft areas in the embankment / subgrade / earthen shoulders, further compaction shall be carried out as directed by the Engineer. If inspite of that the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted to the density requirements and satisfaction of the Engineer.

3.19.4.7Drainage

The surface of the embankment / subgrade at all times during construction shall be maintained at such a cross fall (not flatter than that required for effective drainage of an earthen surface) as will shed water and prevent ponding.

3.19.4.8Repairing of damages caused by rain / spillage of water

The soil in the affected portion shall be removed in such areas as directed by the Engineer before next layer is laid and refilled in layers and compacted using appropriate mechanical means such as small vibratory roller, plate compactor or power rammer to achieve the required density in accordance with Clause 3.19.5. If the cut is not sufficiently wide for use of required mechanical means for compaction, the same shall be widened suitably to permit their use for proper compaction. Tests shall be carried out as directed by the Engineer to ascertain the density requirements of the repaired area. The work of repairing the damages including widening of the cut, if any, shall be carried out by the Contractor at his own cost, including the arranging of machinery / equipment for the purpose.

3.19.4.9Finishing operations

Finishing operations shall include the work of shaping and dressing the shoulders / verge / roadbed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the Drawings or a directed by the Engineer subject to the surface tolerance described in **Clause 902** of MoST Specifications for Roads and Bridge Works (IV Revision). Both the upper and lower ends of the side slopes shall be rounded off to improve appearance and to merge the embankment with the adjacent terrain.

The topsoil, removed and conserved earlier shall be spread over the fill slopes as per directions of the Engineer to facilitate the growth of vegetation. Slopes shall be roughened and moistened slightly prior to the application of the topsoil in order to provide satisfactory bond. The depth of the topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 150 mm.

Where directed, the slopes shall be turfed with sods in accordance with **Clause 3.20**. If seeding and mulching of slopes is prescribed, this shall be done to the requirement of **Clause 3.21**.

When earthwork operations have been substantially completed, the road area shall be cleared of all debris, and ugly scars in the construction area responsible for objectionable appearance eliminated.

3.19.5 Construction of Embankment and Subgrade under Special Conditions

3.19.5.1Earthwork for widening existing road embankment

When an existing embankment and / or subgrade is to be widened and its slope are steeper than 1 vertical on 4 horizontal, continuous horizontal benches, each at least 300 mm wide, shall be cut into the old slope for ensuring adequate bond with the fresh embankment / subgrade material to be added. The material obtained from cutting of benches could be utilized in the widening of the embankment / subgrade. However, when the existing slope against which the fresh material is to be placed is flatter than 1 vertical on 4 horizontal, the slope surface may only be ploughed or scarified instead of resorting to benching.

Where the width of the widened portions is insufficient to permit the use of conventional rollers, compaction shall be carried out with the help of small vibratory rollers / plate compactors / power rammers of any other appropriate equipment approved by the Engineer. End dumping of material from trucks for widening operations shall be avoided except in difficult circumstances when the extra width is too narrow to permit the movement of any other types of hauling equipment.

3.19.5.2Earthwork for embankment and subgrade to be placed against sloping ground:

Where an embankment / subgrade is to be placed against sloping ground, the latter shall be appropriately benched or ploughed / scarified as required in **Clause 3.19.5** before placing the embankment / subgrade material. Extra earthwork involved in benching or due to ploughing / scarifying etc. shall be considered incidental to the work.

For wet conditions, benches with slightly inward fall subsoil drains at the lowest point shall be provided as per the Drawings, before the fill is placed against sloping ground.

3.19.5.3Earthwork over existing road surface:

Where the embankment is to be placed over an existing road surface, the work shall be carried out as indicated below:

If the existing road surface is of granular or bituminous type and lies within 1 m of the new subgrade level, the same shall be scarified to a depth of 50 mm or more if specified, so as to provide ample bond between the old and new material ensuring that at least 500 mm portion below the top of new subgrade level is compacted to the desired density.

If the existing road surface is of cement concrete type and lies within 1 m of the new subgrade level the same shall be removed completely.

If the level difference between the existing road surface and the new formation level is more than 1 m, the existing surface shall be permitted to stay in place without any modification.

3.19.5.4Embankment and subgrade around structures:

To avoid interference with the construction of abutments, wing walls or return walls of culvert / bridge structures, the Contractor shall, at points to be determined by the Engineer suspend work on embankment forming approaches to such structures, until such time as the construction of the latter is sufficiently advanced to permit the completion of approaches without the risk of damage to the structure.

Unless directed otherwise, the filling around culverts, bridges and other structures up to a distance of twice the height of the road from the back of the abutment shall be carried out independent of the work on the main embankment. The fill material shall not be placed against any abutment or wing wall, unless permission has been given by the Engineer but in any case not until the concrete or masonry has been in position for 14 days. The embankment and subgrade shall be brought up simultaneously in equal layers on each side of the structure to avoid displacement in equal layers on each side of the structure to avoid displacement and unequal pressure. The sequence of work in this regard shall be got approved from the Engineer.

The material used for backfill shall not be an organic soil or highly plastic clay having plasticity index and liquid limit more than 20 and 40 respectively when tested according to IS: 2720 (Part 5). Filling behind abutments and wing walls for all structures shall conform to the general guidelines given in Appendix 6 of IRC:78 (Standard Specifications and Code of Practice for Road Bridges-Section VII) in respect of the type of material, the extent of backfill, its laying and compaction etc. The fill material shall be deposited in horizontal layers in loose thickness and compacted thoroughly to the requirements of **Table-II.**

Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter shall conform to the requirements for filter medium spelt out in **Clause 2502** of MoST Specifications for Roads and Bridge Works (IV Revision) unless otherwise specified in the Contract.

Where it may be impracticable to use conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory roller, plate compactor or power rammer. Care shall be taken to see that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to them or excessive pressure against the structure.

3.19.5.5 Construction of Embankment over Ground Incapable of Supporting Construction Equipment:

Where embankment is to be constructed across ground which will not support the weight of repeated heavy loads of construction equipment, the first layer of the fill may be constructed by placing successive loads of material in a uniformly distributed layer of a minimum thickness required to support the construction equipment as permitted by the Engineer. The Contractor, if so desired by him, may also use suitable geosynthetic material to increase the bearing capacity of the foundation. This exception to normal procedure will not be permitted where, in the opinion of the Engineer, the embankments could be constructed in the approved manner over such ground by the use of lighter or modified equipment after proper ditching and drainage have been provided. Where this exception is permitted, the selection of the material and the construction procedure to obtain an acceptable layer bshall be the responsibility of the Contractor. The cost of providing suitable traffic conditions for construction equipment over any area of the Contract will be the responsibility of the Contractor and no extra payment will be made to him. The remainder of the embankment shall be constructed as specified in Clause 3.19.4.

3.19.5.6Embankment construction under water

Where filling or backfilling is to be placed under water, only acceptable granular material or rock shall be used unless otherwise approved by the Engineer. Acceptable granular material shall consist of graded, hard durable particles with maximum particle size not exceeding 75 mm. The material should be non-plastic having uniformity coefficient of not less than 10. The material placed in open water shall be deposited by end tipping without compaction.

3.19.5.7Earthwork for high embankment

In the case of high embankments, the Contractor shall normally use the material from the specified borrow area. In case he desires to use different material for his own convenience, he shall have to carry out necessary soil investigations and redesign the high embankment at his own cost. The Contractor shall then furnish the soil test data and design of high embankment for approval of the Engineer, who reserve the right to accept or reject it.

If necessary, stage construction of fills and any controlled rates of filling shall be carried out in accordance with the Contract including installation of instruments and its monitoring.

Where required, the Contractor shall surcharge embankments or other areas of till with approved material for the periods specified in the Contract. If settlement of surcharged fill results in any surcharging material, which is unacceptable for use in the fill being surcharged, lying below formation level, the Contractor shall remove the unacceptable material and dispose it as per direction of the Engineer. He shall then bring the resultant level up to formation level with acceptable material.

3.19.5.8Settlement period

Where settlement period is specified in the Contract, the embankment shall remain in place for the required settlement period before excavating for abutment, wingwall, retaining wall, footings, etc., or driving foundation piles. The duration of the required settlement period at each location shall be as provided for in the Contract or as directed by the Engineer.

3.19.6 Plying of Traffic

Construction and other vehicular traffic shall not use the prepared surface of the embankment and / or subgrade without the prior permission of the Engineer. Any damage arising out of such use shall, however, be made good by the Contractor at his own expense as directed by the Engineer.

3.19.7 Surface Finish and Quality Control of Work

The surface finish of construction of subgrade shall conform to the requirements of Clause 902 of MoST Specifications for Roads and Bridge Works (IV Revision). Control on the quality of materials and works shall be exercised in accordance with Clause 903 of MoST Specifications for Roads and Bridge Works (IV Revision).

3.19.8 Subgrade Strength

It shall be ensured prior to actual execution that the borrow area material to be used in the subgrade satisfies the requirements of design CBR.

Subgrade shall be compacted and finished to the design strength consistent with other physical requirements. The actual laboratory CBR values of constructed subgrade shall be determined on undisturbed samples cut out from the compacted subgrade in CBR mould fitted with cutting shoe or on remoulded samples, compacted to the field density at the field moisture content.

3.19.9 Measurements for Payment

Earth embankment/subgrade construction shall be measured separately by taking cross sections at intervals in the original position before the work starts and after its completion and computing the volumes of earthwork in cubic metres by the method of average end areas.

The measurement of fill material from borrow areas shall be the difference between the net quantities of compacted fill and the net quantities of suitable material brought from roadway and drainage excavation. For this purpose, it shall be assumed that one cum. of suitable material brought to site from road and drainage excavation forms one cum. of compared fill and all bulking or shrinkage shall be ignored.

Construction of embankment under water shall be measured in cum.

Construction of high embankment with specified material and in specified manner shall be measured in cum.

Stripping including storing and reapplication of topsoil shall be measured in cum.Work involving loosening and recompacting of ground supporting embankment / subgrade shall be measured in cum.

Removal of unsuitable material at embankment / subgrade foundation and replacement with suitable material shall be measured in cum.

Scarifying existing granular / bituminous road surface shall be measured in square metres.

Dismantling and removal of existing cement concrete pavement shall measured vide Clause 202.6 of MoST Specifications for Roads and Bridge Works (IV Revision).

Filter medium and backfill material behind abutments, wing walls and other retaining structures shall be measured as finished work in position in cum.

3.19.10 Rates

The Contract unit rates for the items of embankment and subgrade construction shall be payment in full for carrying out the required operations including full compensation for:

Cost of arrangement of land as a source of supply of material of required quantity for construction unless provided otherwise in the Contract;

Setting out;

Compacting ground supporting embankment / subgrade except where removal and replacement of unsuitable material or loosening and recompacting is involved;

Scarifying or cutting continuous horizontal benches 300 mm wide on side slopes of existing embankment and subgrade as applicable;

Cost of watering or drying of material in borrow areas and / or embankment and subgrade during construction as required.

Spreading in layers bringing to appropriate moisture content and compacting to Specification requirements;

Shaping and dressing top and slopes of the embankment and subgrade including rounding of corners;

Restricted working at sites of structures;

Working on narrow width of embankment and subgrade;

Excavation in all soils from borrow pits / designated borrow areas including clearing and grubbing and transporting the material to embankment and subgrade site with all lifts and leads unless otherwise provided for in the Contract;

All labour, materials, tools, equipment and incidentals necessary to complete the work to the Specifications;

Dewatering; and

Keeping the embankment / completed formation free of water as per Clause 5.25.

In case the Contract unit rate specified is not inclusive of all leads, the unit rate for transporting material beyond the initial lead, as specified in the Contract for construction of embankment and subgrade shall be inclusive of full compensation for all labour, equipment, tools and incidentals necessary on account of the additional haul or transportation involved beyond the specified initial lead.

The Contract unit rate for the items of stripping and storing topsoil and of reapplication of topsoil shall include full compensation for all the necessary operations including all lifts, but leads up to 1000 m.

The contract unit rate for loosening and recompacting the loosened materials at subgrade shall include full compensation for loosening to the specified depth, including breaking clods, spreading in layers, watering where necessary and compacting to the requirements.

The Contract unit rate for scarifying existing granular / bituminous road surface shall be payment in full for carrying out the required operations including full compensation for all labour, materials, tools, equipment and incidentals necessary to complete the work. This will also comprise of handling, salvaging, stacking and disposing of the dismantled materials within all lifts and up to a lead of 1000 m or as otherwise specified.

Clause 202.7 of MoST Specifications for Roads and Bridge Works (IV Revision) shall apply as regards Contract unit rate for dismantling and removal of existing cement concrete pavement.

The Contract unit rate for providing and laying filters material behind abutments shall be payment in full for carrying out the required operations including all materials, labour, tools, equipment and incidentals to complete the work to Specifications.

Clause 3.19.5 shall apply as regards Contract unit rate for construction of embankment under water.

Clause 3.19.5 shall apply as regards Contract unit rate for construction of high embankment. It shall include cost of instrumentation, its monitoring and settlement period, where specified in the Contract or directed by the Engineer.

3.20 Soil Erosion and Sedimentation Control

3.20.1 Scope

This work shall consist of measures as shown on plans or as directed by the Engineer to control soil erosion, sedimentation and water pollution, through use of berms, dikes, sediment basins, fibre mats, mulches, grasses, slope drains, and other devices.

3.20.2 Materials

All materials shall meet commercial grade standards and shall be approved by the Engineer before being used in the work.

3.20.3 Construction Operations

Prior to the start of the relevant construction, the Contractor shall submit to the Engineer for approval his schedules for carrying out temporary and permanent erosion / sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment / subgrade construction, bridges and other structures across water course, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion / sedimentation control on service road and borrowpits and his plan for disposal of waste materials. Work shall not be started until the erosion / sedimentation control schedules and methods of operations for the applicable construction have been approved by the Engineer.

The surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and fill operations shall be limited to the extent practicable. The Contractor may be directed to provide immediate permanent or temporary erosion and sedimentation control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other water courses, lakes, reservoirs etc. Such work may involve the construction of temporary berms, dikes, sediment basins, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation. Cut and fill slopes shall be seeded and turfed as required on the plans.

The Contractor shall be required to incorporated all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures.

Temporary erosion / sedimentation and pollution control measures will be used to control the phenomenon of erosion, sedimentation and pollution that may develop during normal construction practices, but may neither be foreseen during design stage nor associated with permanent control features on the Project.

Where erosion or sedimentation is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion or sedimentation control features can follow immediately thereafter if the project conditions permit; otherwise temporary erosion or sedimentation control measure may be required between successive construction stages. Under no conditions shall a large surface area of erodible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the Engineer.

The Engineer may limit the area of excavation, borrow and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding and other such permanent erosion, sedimentation and pollution control measures, in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion / sedimentation control measures shall be taken immediately to the extent feasible and justified.

In the event temporary erosion, sedimentation and pollution control measures become necessary due to the Contractor's negligence, carelessness or failure to install permanent controls as a part of the

work as scheduled or ordered by the Engineer, these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness of failure to install permanent controls, will be performed as ordered by the Engineer.

Temporary erosion, sedimentation and pollution control may include construction work outside the right-of-way where such work is necessary as result of road construction such as borrow pit operations, service roads and equipment storage sites.

The temporary erosion, sedimentation and pollution control features installed by the Contractor shall be acceptably maintained by him till these are needed, unless otherwise agreed by the Engineer.

3.20.4 Measurements for Payment

The soil erosion, sedimentation and pollution control works will be measured in terms of units specified in the Bill of Quantities for the respective items.

3.20.5 Rates

The contract unit rate for different items of soil erosion, sedimentation and pollution control works shall be payment in full for carrying out all required operations including full compensation for all labour, tools, equipment and incidents to complete the works to the Specifications.

3.21 Turfing with Sods

3.21.1 Scope

This work shall consist of furnishing and laying of the live sod of perennial turf forming grass on embankment slopes, verges (earthen shoulders) or other locations shown on the Drawings or as directed by the Engineer. Unless otherwise specified, the work shall be taken up as soon as possible following construction of the embankment, provided the season is favourable for establishment of the sod.

3.21.2 Materials

The sod shall consist of dense, well-rooted growth of permanent and desirable grasses, indigenous to the locality where it is to be use, and shall be practically free from weeds or other undesirable matter. At the time the sod is cut, the grass on the sod shall have a length of approximately 50 mm and the sod shall have freed of debris.

Thickness of the sod shall be as uniform as possible, with some 50-80 mm or so of soil covering the grass roots depending on the nature of the sod, so that practically all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width, not less than about 250 mm X 300 mm in size but not so large that it is inconvenient to handle and transport these without damage. During wet weather, the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

3.21.3 Construction Operations for Turfing with Sods

Preparation of earth bed

The area to be sodded shall have been previously constructed to the required slope and cross section. Soil on the area shall be loosened, freed of all stones larger than 50 mm size, sticks, stumps and any undesirable foreign matter, and brought to a reasonably fine granular texture to a depth of not less than 25 mm for receiving the sod.

Where required, topsoil shall be spread over the slopes. Prior to placing the topsoil, the slopes shall be scarified to a depth which, after settlement, will provide the required nominal depth shown on the plans. Spreading shall not be done when the ground is excessively wet.

Following soil preparation and top soiling, where required, fertilizer and ground limestone when specified shall be spread uniformly at the rate indicated on the plans. After spreading, the materials are incorporated in the soil by discing or other means to the depths shown on the plans.

Placing the sods

The prepared sod bed shall be moistened to the loosened depth, if not already sufficiently moist, and the sod shall be placed thereon within approximately 24 hours after the same had been cut. Each sod strip shall be laid edge to edge and such that the joints caused by abutting ends are staggered. Every strip, after it is snugly placed against the strips already in position, shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil.

On side slopes steeper than 2 (horizontal) to 1 (vertical), the laying of sods shall be started from bottom upwards. At points where water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over this followed by its through compaction.

Staking the sods

Where the side slope is 2 (horizontal) to 1 (vertical) or steeper and the distance along the slope is more than 2 m, the sods shall be staked with pegs or nails spaced approximately 500 to 1000 mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

Top dressing

After the sods have been laid in position, the surface shall be cleaned of loose sod, excess soil and other foreign material. Thereafter, a thin layer of topsoil shall be scattered over the surface of top dressing and the area thoroughly moistened by sprinkling with water.

Watering and maintenance

The sods shall be watered by the Contractor for a period of at least four weeks after laying. Watering shall be so done as to avoid erosion and prevent damage to sodded areas by wheels of water tanks.

The Contractor shall erect necessary warning signs and barriers, repair or replace sodded areas failing to show uniform growth of grass or damaged by his operations and shall otherwise maintain the sod at his cost until final acceptance.

Measurement for Payment

Turfing with sods shall be measured as finished work in square metres.

Rate

The Contract unit rate for turfing with sods shall mean payment in full for carrying out all the required operations explained above including compensation for:

Furnishing all the materials to be incorporated in the Works with all leads and lifts; and

All labour, tools, equipment and incidental to complete the work in accordance with these Specifications.

3.22 Seeding and Mulching

3.22.1 Scope

This shall consist of preparing slopes, placing topsoil, furnishing all seeds, commercial or organic fertilizers and mulching materials, providing jute netting and placing and incorporation the same on embankment slopes or other locations designated by the Engineer or shown in the Contract documents.

3.22.2 Materials

Seeds

The seeds shall be approved quality and type suitable for the soil on which these are to be applied, and shall have acceptable purity and germination to requirements set down by the Engineer.

Fertilizer

This shall consist of standard commercial materials and conform to the grade specified. Organic manure shall be fully purified organic matter such as cow dung.

Mulching materials

This shall consist of straw, hay wood shavings or sawdust and shall be delivered dry. They shall be reasonably free of weed seed and such foreign materials as may detract from their effectiveness as mulch or be injurious to the plant growth.

Topsoil

Topsoil shall not be obtained from an area known to have noxious weeds growing in it. If treated with herbicides or sterilents, it shall be got tested by appropriate agricultural authority to determine the residual in the soil. Topsoil shall be contain less than 2 per cent and more than 12 per cent organic matter.

Bituminous Emulsion

A suitable grade of bituminous cutback or emulsion used as a tie down for mulch shall be as described in the Contract document or as desired by the Engineer. Emulsified bitumen shall not contain any solvent or diluting agent toxic to plant life.

Netting

Jute netting shall be undyed jute yam woven into a uniform open weave with approximate 2.5 cm square openings. Geonetting shall be made of uniformly extruded rectangular mesh having mesh opening of 2 cm x 2 cm. The colour may be black or green. It shall weigh not less than 3.8 kg per 1000 sq. m.

3.22.3 Seeding Operations

Seed-bed Preparation

The area to be seeded shall be brought to the required slope and cross-section by filling, reshaping eroded areas and refinishing slopes, median etc. Topsoil shall be evenly spread over the specified areas to the depth shown on the plans, unless otherwise approved by the Engineer. The see-bed preparation shall consist of eliminating all live plants by suitable means using agricultural implements. All stones 150 mm in smallest dimension and larger shall be removed. The soil shall be excavated on the contour to a depth of 100 mm. All clods large than 25 mm in diameter shall be crushed and packed. Where necessary, water shall then be applied. All topsoil shall be compacted unless otherwise specified or approved by the Engineer. Compaction shall be by slope compactor, cleated tractor or similar equipment approved by the Engineer. Equipment shall be so designed and constructed as to produce a uniform rough textured surface ready for seeding and mulching and which will bond the topsoil to the underlying material. The entire area shall be covered by a minimum of 4 passes or 2 round trips of the roller or approved equipment.

Fertilizer application

Fertilizer to the required quantities shall be spread and thoroughly incorporated into the soil surface as a part of the seed-bed preparation.

Planting of seeds

All seeds shall be planted uniformly at the approved rate. Immediately after sowing, the area shall be raked, dragged or otherwise treated so as to cover the seeds to a depth of 6 mm. The operation of seed sowing shall not be performed when the ground is muddy or when the soil or weather conditions would otherwise prevent proper soil preparation and subsequent operations.

Soil Moisture and Watering requirements

Soil moisture shall exist throughout the zone from 25 mm to at least 125 mm below the surface at the time of planting. Watering off the seeded areas shall be carried out as determined by the Engineer.

Mulching, Applying Bituminous Emulsion and Jute Netting / Geonetting

Within 24 hours of seeding, mulching material mixed with organic manure shall be placed so as to form a continuous, unbroken cover of approximate uniform thickness of 25 mm using an acceptable mechanical blower. Mulching material shall be held in place and made resistant to being blown away by suitable means approved by the Engineer. When called for in the Contract documents, mulch material shall be anchored in place with bituminous emulsion applied at the rate of 2300 liters per hectare. Any mulch disturbed or displaced following application shall be removed, reseeded and remulched as specified. Jute netting / Geonetting shall be unrolled and placed parallel to the flow of water immediately following the bringing, to finished grade, the area specified on the plans or the placing of seed and fertilizer. Where more than one strip is required to cover the given areas, they

shall overlap a minimum of 100 mm. Jute netting / Geonetting shall be held in place by approved wire staples, pins, spikes or wooden stakes driven vertically into the soil

Maintenance

The Contractor shall maintain all seeded and mulched areas until final acceptance. Maintenance shall include protection of traffic by approved warning signs or barricades and repairing any areas damaged following the seeding and mulching operations. If mulched areas become damaged, the area shall be reshaped and then seeded and mulched again as originally specified.

Measurement for payment

Seeding and mulching shall be measured as finished work in square metres.

Rate

The Contract unit rate for seeding and mulching shall be payment in full for carrying out all the required operations including full compensation for all materials, labour, tools and incidentals.

Preparation and Surface Treatment of Formation

Preparation and surface treatment of the formation, that is top of the subgrade, shall be carried out only after completion of any specified subgrade drainage and unless otherwise agreed by the Engineer, immediately prior to laying the sub-base or the road base where no sub-base is required. The sequence of operations shall be as follows:

All surfaces below carriageway, lay byes, footways and hard shoulders shall, after reinstatement of any soft areas to the required Specifications be well cleaned and freed of mud and slurry.

The surface shall be compacted by 4 passes of a smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required, before the commencement of rolling.

The formation shall, wherever necessary, be regulated and trimmed to the requirements of **Clause 5.20.4.9** with motor grader.

The trimmed formation shall be rolled by one pass of smooth wheeled roller of 80 to 100 kN weight after spraying requisite amount of water, if required, before the commencement of rolling.

Where the completed formation is not immediately covered with sub base or road base material, its moisture content shall be maintained to prevent cracking in the formation by suitable measures as approved by the Engineer. The entire work of surface treatment of formation shall be deemed as incidental to the work of sub-base / base course to be provided on the subgrade and as such no extra payment shall be made for the same.

Works to be Kept Free of Water

The Contractor shall arrange for the rapid dispersal of water collected / accumulated on the earthwork or completed formation during construction or on the existing roadway or which enters the earthwork or any other item of work from any source, and where practicable, the water shall be discharged into the permanent outfall of the drainage system. The arrangement shall be made in respect of all earthwork including excavation for pipe trenches, foundations or cuttings.

The Contractor shall provide, where necessary, temporary water courses, ditches, drains, pumping or other means for maintaining the earthwork free from water. Such provisions shall include carrying

out the work of forming the cut sections and embankments in such manner that their surfaces have at all times a sufficient minimum crossfall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding.

The works involved in keeping the earthwork or any other item of works free of water shall be deemed as incidental to the respective item of work and as such no separate payment shall be made for the same.

3.23 Site Filling

3.23.1 Sand fill

Sandy fill shall be deposited to bring the grade level to the desired elevation after compaction of fill. Sandy fill shall be carried out in one of the following methods as detailed in the drawings:

Compaction of sandy fill by flooding the area shall be carried out where so specified. In this case, Contractor should ensure that the fill material is not washed away. This work shall be carried out as directed by Engineer.

Sandy fill shall be compacted where so specified by 12 tonne vibrating rollers. The fill material shall be compacted to the required density.

If the density of fill or use of rollers for compaction is not specified, Contractor shall ensure necessary compaction by the passage of trucks, carrying the fill material over the deposited fill in such a way that the entire fill area is covered. This will reasonably compact the sand fill and will be accepted by Engineer. However, Contractor shall ensure that every layer is thus compacted before the succeeding layers are deposited. Each layer shall not exceed 200mm in thickness.

3.23.2 Soil fill

Approved soil fill consisting of ordinary soil, murrum, soil containing gravel, shingle, etc. shall be deposited in layers not exceeding 200mm. Contractor should ensure that all clods of earth are broken down to a size not larger than 100mm.

Where density of fill or use of rollers is not specified, the fill shall be carried out as specified above.

Where specified, the required density to fill shall be obtained by proper compaction.

3.23.3 Measurement

Measurement shall be made on the basis of Clause 3.13.

End of Section 3

SECTION 4

CONCRETE AND ALLIED WORKS

SECTION - 4

CONCRETE AND ALLIED WORKS

4.1 Applicable Codes

4.1.1 Materials

1)	IS: 269	Specification for 33 grade ordinary Portland cement.
2)	IS: 455	Specification for Portland slag cement.
3)	IS: 1489	Specification for Portland-pozzolana cement (Part 1&2).
4)	IS: 8112	Specification for 43 grade ordinary Portland cement.
5)	IS: 12269	Specification for 53 grade ordinary Portland cement.
6)	IS: 12330	Specification for sulphate resisting Portland cement.
7)	IS: 383	Specification for coarse and fine aggregates from natural sources for concrete.
8)	IS: 432	Specification for mild steel and medium (tensile steel bars and hard-drawn steel) wires for concrete reinforcement. (Part 1 and 2)
9)	IS: 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
10)	IS: 1566	Specification for hard-drawn steel wire fabric for concrete reinforcement.
11)	IS: 9103	Specification for admixtures for concrete.
12)	IS: 2645	Specification for integral cement water- proofing compounds for cement motar
13)	IS: 4990	Specification for plywood for concrete shuttering work.

4.1.2 Material Testing

1)	IS.4031	Methods of physical tests for hydraulic cement (Parts 1 to 15)
2)	IS: 4032	Method chemical analysis of hydraulic cement.
3)	IS: 650	Specification for standard sand for testing of cement.
4)	IS: 2430	Methods for sampling of aggregates for concrete.
5)	IS: 2386	Methods of test for aggregates for concrete (Parts 1 to 8)
6)	IS: 3025	Methods of sampling and test (physical and chemical) for water used in industry.
7)	IS: 6925	Methods of test for determination of water soluble chlorides in concrete admixtures.

4.1.3 Material Storage

1)	IS: 4082	Recommendations on stacking and storing of construction materials and components at site

4.1.4 Concrete Mix Design

1)	IS: 10262	Recommended guidelines for concrete mix design.
2)	SP: 23 (S&T)	Handbook on Concrete Mixes.

4.1.5 Concrete Testing

1) IS.1199 Method of sampling and analysis of concrete.
2) IS: 516 Method of test for strength of concrete.
3) IS: 9013 Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
4) IS: 8142 Method of test for determining setting time of concrete by penetration resistance.
5) IS: 9284 Method of test for abrasion resistance of concrete.
6) IS: 2770 Methods of testing bond in reinforced concrete. Part I-Pullout test
7) IS: 2911 Code of Practice for design and construction of Pile foundations (Part 4)

4.1.6 Equipments

1) IS: 1791 General Requirements for batch type concrete mixers.
2) IS: 2438 Specification for roller pan mixer.
3) IS: 4925 Specification for concrete batching and mixing plant.
4) IS: 5892 Specification for concrete transit mixer and agitator.
5) IS: 7242 Specification for concrete spreaders.
6) IS: 2505 General Requirements for concrete vibrators: Immersion type.
7) IS: 2506 General Requirements for screed board concrete vibrators.
8) IS: 2514 Specification for concrete vibrating tables.
9) IS: 3366 Specification for pan vibrators.
10) IS: 4656 Specification for form vibrators for concrete.
11) IS: 11993 Code of practice for use of screed board concrete vibrators.
12) IS: 7251 Specification for concrete finishers.
13) IS: 2722 Specification for portable swing weigh batchers for concrete (single and double bucket type).
14) IS: 2750 Specification for steel scaffoldings.

4.1.7 Codes of Practice

1) IS: 456 Code of practice for plain and reinforced concrete.
2) IS: 457 Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
3) IS: 3370 Code of practice for concrete structures for storage of liquids (Parts 1 to 4)
4) IS: 3935 Code of practice for composite construction.
5) IS: 2204 Code of practice for construction of reinforced concrete shell roof.
6) IS: 2210 Criteria for the design of reinforced concrete shell structures and folded plates.
7) IS: 2502 Code of practice for bending and fixing of bars for concrete reinforcement.
8) IS: 5525 Recommendation for detailing of reinforcement in reinforced concrete works.
9) IS: 2751 Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.
10) IS: 9417 Specification for welding cold worked bars for reinforced concrete construction.
11) IS: 3558 Code of practice for use of immersion vibrators for consolidating concrete.
12) IS: 3414 Code of practice for design and installation of joints in buildings.
13) IS: 4326 Code of practice for earthquake resistant design and construction of building.
14) IS: 4014 Code of practice for steel tubular scaffolding (Parts 1 & 2)
15) IS: 2571 Code of practice for laying insitu cement concrete flooring.
16) IS: 7861 Code of practice for extreme weather concreting: Part 1 Recommended practice for hot weather concreting.

17) IS: 2911 Code of Practice for design and construction of Pile foundations
18) SP: 16 – 1980 Design Aids for Reinforced Concrete To IS 456: 1978
19) SP: 34 – 1987 Handbook on Concrete Reinforcement and Detailing

4.1.8 Construction Safety

1) IS: 3696 Safety code for scaffolds and ladders. (Parts 1 & 2)
2) IS: 7969 Safety code for handling and storage of building materials.
3) IS: 8989 Safety code for erection of concrete framed structures.

4.1.9 Measurement

1) IS 1200 Method of measurement of building and Engineering works
2) IS 3385 Code of practice for measurement of Civil Engineering works

4.2 General

The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, layout and storage of materials, the concrete batching and mixing equipment and the quality control system. Such an inspection shall be arranged and the Engineer's approval obtained, prior to starting of concrete work. This shall, however, not relieve the Contractor of any of his responsibilities. All materials which do not conform to the Specifications shall be rejected.

Materials should be selected so that they can satisfy the design requirements of strength, serviceability, safety, durability and finish with due regards to the functional requirements and the environmental conditions to which the structure will be subjected. Materials complying with codes/standards shall generally be used. Other materials may be used after approval of the Engineer and after establishing their performance suitability based on previous data, experience or tests.

4.3 Materials

4.3.1 Cement

Unless otherwise called for by the Engineer, cement shall be ordinary Portland cement conforming to IS: 269, IS: 8112 or IS: 12269.

Where Portland pozzolana or slag cements are used, it shall be ensured that consistency of quality is maintained, there will be no adverse interactions between the materials and the finish specified is not marred.

Only one type of cement shall be used in any one mix. The source of supply, type or brand of cement within the same structure or portion thereof shall not be changed without approval from the Engineer.

Cement which is not used within 90 days from its date of manufacture shall be tested at a laboratory approved by the Engineer and until the results of such tests are found satisfactory, it shall not be used in any work.

4.3.2 Aggregates (General)

Aggregates shall consist of naturally occurring stones (crushed or uncrushed), gravel and sand. They shall be chemically inert, strong, hard, clean, durable against weathering, of limited porosity, free from

dust/silt/ organic impurities/deleterious materials and conform to IS: 383. Aggregates such as slag, crushed over burnt bricks, bloated clay ash, sintered fly ash and tiles shall not be used.

Aggregates shall be washed and screened before use where necessary or if directed by the Engineer. Aggregates containing reactive materials shall be used only after tests conclusively prove that there will be no adverse effect on strength, durability and finish, including long term effects, on the concrete.

The fineness modulus of sand shall neither be less than 2.2 nor more than 3.2.

The maximum size of coarse aggregate shall be as stated on the drawings but in no case greater than 1/4 of the minimum thickness of the member.

Plums 160 mm and above of a reasonable size may be used in mass concrete fill where directed. Plums shall not constitute more than 20% by volume of the concrete.

4.3.3 Water

Water used for both mixing and curing shall conform to IS: 456. Potable waters are generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used.

4.3.4 Reinforcement

In general, reinforcement for buildings and sewage treatment units shall be HYSD-CRS (Corrosion Resistant Steel) of Grade Fe 500. All physical and chemical properties of this Fe 500 grade steel shall conform to IS: 1786-2008. Welded wire fabric shall conform to IS: 1566 as shown or specified on the drawing.

The CRS (corrosion resistant steel) index shall be at least 1.35 when tested for Salt Spray test as per "ASTM B 117 – 2009 test procedure for 120 hours when compared with the Fe 500 normal reinforcement bars and with same bar diameter. Test results have to be produced for the respective bar diameter for each consignment of steel delivered at site and at a frequency of every 20 Metric Tons.

Reinforcement bars produced using iron ore as the basic raw material only will be accepted. The manufacturer of Reinforcement bars must fall into the category of primary steel producer as defined by Ministry of Steel, Government of India.

All reinforcement shall be clean, free from pitting, oil, grease, paint, loose mill scales, rust, dirty, dust, or any other substance that will destroy or reduce bond.

4.3.5 Admixtures

Accelerating, retarding, water-reducing and air entraining admixtures shall conform to IS: 9103 and integral water proofing admixtures to IS: 2645.

Admixtures may be used in concrete as per manufacturer's instructions only with the approval of the Engineer. An admixture's suitability and effectiveness shall be verified by trial mixes with the other materials used in the works. If two or more admixtures are to be used simultaneously in the same concrete mix, their interaction shall be checked and trial mixes done to ensure their compatibility. There should also be no increase in risk of corrosion of the reinforcement or other embedment.

Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride is permitted such as in mass concrete works, it shall be dissolved in water and added to the mixing water by an amount not exceeding 1.5 percent of the weight of the cement in each batch of concrete. The designed concrete mix shall be corrected accordingly.

4.4 Wastage

Wastage allowance for cement and steel and higher rolling margin for steel shall be considered in the item rate and no extra payment shall become payable to the Contractor on any account.

4.5 Samples and Tests

All materials used for the works shall be tested before use. Manufacturer's test certificate shall be furnished for each batch of cement/steel and when directed by the Engineer samples shall also be got tested by the Contractor in a laboratory approved by the Engineer at no extra cost to Employer. Sampling and testing shall be as per IS: 2386 under the supervision of the Engineer. Water to be used shall be tested to comply with requirements of IS: 456.

The Contractor shall furnish manufacturer's test certificates and technical literature for the admixture proposed to be used. If directed, the admixture shall be got tested at an approved laboratory at no extra cost.

4.6 Storing of Materials

All materials shall be stored in a manner so as to prevent its deterioration and contamination which would preclude its use in the works. Requirements of IS: 4082 shall be complied with.

The Contractor will have to make his own arrangements for the storage of adequate quantity of cement. If such cement is not stored properly and has deteriorated, the material shall be rejected. Cement bags shall be stored in dry weatherproof shed with a raised floor, well away from the outer walls and insulated from the floor to avoid moisture from ground. Not more than 15 bags shall be stacked in any tier. Storage arrangement shall be approved by the Engineer. Storage under tarpaulins shall not be permitted. Each consignment of cement shall be stored separately and consumed in its order of receipt.

Each size of coarse and fine aggregates shall be stacked separately and shall be protected from leaves and contamination with foreign material. The stacks shall be on hard, clean, free draining bases, draining away from the concrete mixing area.

The Contractor shall make his own arrangements for storing water at site in tanks to prevent contamination.

The reinforcement shall be stacked on top of timber sleepers to avoid contact with ground/water. Each type and size shall be stacked separately.

4.7 Concrete

4.7.1 General

Concrete grade shall be as designated on drawings. In concrete grade M15, M20 etc. the number represents the specified characteristic compressive strength of 150 mm cube at 28 days, expressed in N/sq.mm as per IS:456. Concrete in the works shall be "DESIGN MIX CONCRETE" or "NOMINAL MIX CONCRETE". All concrete works of grade M5, M7.5, M10 and M15 shall be NOMINAL MIX CONCRETE whereas all other grades, M20 and above, shall be DESIGN MIX CONCRETE.

The grades of concrete to be used are noted on the drawings. In addition, the following table shall apply unless specified otherwise.

Structure	Grade of Concrete	Max. Aggregate Size
1. All Waste water retaining structures / box culverts, etc.	M30	20 mm
2. Sewage Pumping Station (Where concrete is in contact with Sewage)		
(a) for foundation raft	M30	40 mm
(b) for walls, columns, floor beams, circular floor slab	M30	20 mm
(c) for beams, slabs etc.	M30	20 mm
3. Valve chambers and pipe trenches		
(a) for foundation raft	M25	40 mm
(b) walls, columns	M25	20 mm
(c) for slabs, beams, etc.	M25	20 mm
4. Anchor blocks on pipeline, base slab of storm water drain	M15	40 mm
5. Saddles	M20	20 mm
6. Pipeline embankment, grade slab, ramps, footings under walls, SW drain coping etc	M15	20 mm
7. Bridges		
Foundation of piers and abutments	M25	40 mm
Piers and abutments with wing walls	M25	40 mm
Hammer head of pipes	M25	40 mm
9. Causeway	M20	20 mm

Structure	Grade of Concrete	Max. Aggregate Size
10. Other General Buildings		
(a) for foundation raft	M25	40 mm
(b) walls, columns	M25	20 mm
(c) for slabs, beams, etc.	M25	20 mm

4.7.2 Design Mix Concrete

(a) Mix Design & Testing

For Design Mix Concrete, the mix shall be designed according to IS: 10262 and SP:23 to provide the grade of concrete having the required workability and characteristic strength not less than appropriate values given in IS:456. The design mix shall in addition be such that it is cohesive and does not segregate and should result in a dense and durable concrete and also capable of giving the finish as specified. For liquid retaining structures, the mix shall also result in water tight concrete. The Contractor shall exercise great care while designing the concrete mix and executing the works to achieve the desired result.

The minimum cement content for Design Mix Concrete shall be as per Table-5 of IS: 456 or as given below, whichever is higher.

Grade of Concrete	Minimum Cement Content in Kg/Cu.m of Concrete
M15	260
M20	315
M25	360
M30	375

The minimum cement content stipulated above shall be adopted irrespective of whether the Contractor achieves the desired strength with less quantity of cement. The Contractor's quoted rates for concrete shall provide for the above eventuality and nothing extra shall become payable to the Contractor in this account. Even in the case where the quantity of cement required is higher than that specified above to achieve desired strength based on an approved mix design, nothing extra shall become payable to the Contractor.

The Contractor shall submit details of the source of all material and the proposed quantities of each ingredient per cubic metre of fully compacted concrete. The Contractor shall then make trial mixes for each class of concrete using the same Contractor's Equipment and the same materials as are proposed for the Permanent Works. The Contractor shall give 24 hours notice of such trials to enable the Engineer's Representative to attend. For each trial mix, three separate batches of concrete shall be made by the Contractor and will be tested at 28 days all in accordance with IS: 516. Such trial mixes shall not be the first batch through the plant in any one sequence of concrete production.

The Contractor shall not commence concreting in the Permanent Works until details of trial mixes and test results for each class of concrete have been submitted to and approved by the Engineer.

Unless otherwise specified, only medium graded fine aggregate shall be used

A trial mix design will be approved by the Engineer with respect to strength if the average compressive strength of the nine cubes so tested is more than the target mean strength appropriate to the grade of concrete.

For concrete of Grade 30 and over the Contractor shall cast two sample wall panels 48 hours apart. Each shall be cast in two equal lifts to form a wall panel having one horizontal construction joint formed in the manner proposed by the Contractor for the Works. The top surface of the second lift shall have a Type U3 finish. The panels shall not be touched up after stripping. The panels shall be 300 mm thick and 1.5 m long by 1.5 m high. The Contractor shall not commence concreting in the Permanent Works until the test panels have been approved by Engineer.

The Contractor shall not alter the approved mix proportions nor the approved source of supply of any of the ingredients without having previously obtained the approval of the Engineer.

During production, the Engineer may require trial mixes to be made before a substantial change is made in the materials or in the proportions of the materials to be used.

It shall be the Contractor's sole responsibility to carry out the mix designs at his own cost. He shall furnish to the Engineer at least 30 days before concreting operations, a statement of proportions proposed to be used for the various concrete mixes and the strength results obtained. The strength requirements of the concrete mixes ascertained on 150 mm cubes as per IS:516 shall comply with the requirements of IS:456 as follows :

Grade of Concrete	**Minimum Compressive Strength N/sq.mm at 7 days**	**Specified Characteristic Compressive Strength N/sq.mm at 28 days**
M15	10.0	15.0
M20	13.5	20.0
M25	17.0	25.0
M30	20.0	30.0
M35	23.5	35.0
M40	27.0	40.0

A range of slumps which shall generally be used for various types of construction unless otherwise instructed by the Engineer is given below:

Structure/Member	Slump in millimeters	
	Maximum	Minimum
Reinforced foundation walls and footings	75	40
Plain footings, caissons and substructure walls	75	40
Slabs, Beams and reinforced walls	100	40
Pump & miscellaneous Equipment Foundation	75	40
Building columns	100	40
Pavements	50	40
Heavy mass construction	50	40

Note: All concreting done for water retaining structures shall have a minimum slump value of 60 mm and maximum of 100 mm

(b) Batching & Mixing of Concrete

It is expected that batching plants of minimum 20 m^3 capacity and pumps for placing concrete shall be used. Proportions of aggregates and cement, as decided by the concrete mix design, shall be by weight. These proportions shall be maintained during subsequent concrete batching by means of weigh batchers capable of controlling the weights within one percent of the desired value.

Amount of water added shall be such as to produce dense concrete of required consistency, specified strength and satisfactory workability and shall be so adjusted to account for moisture content in the aggregates. Water- cement ratio specified for use by the Engineer shall be maintained. Each time the work stops, the mixer shall be cleaned out, and while recommencing, the first batch shall have 10% additional cement to allow for sticking in the drum.

Arrangement should be made by the Contractor to have the cubes tested in an approved laboratory or in field with prior consent of the Engineer. Sampling and testing of strength and workability of concrete shall be as per IS:1199, IS:516 and IS:456.

4.7.3 Nominal Mix Concrete

(a) Mix Design & Testing

Mix design and preliminary tests are not necessary for Nominal Mix Concrete. However works tests shall be carried out as per IS:456. Proportions for Nominal Mix Concrete and W/C ratio may be adopted as per Table 9 of IS:456. However it will be the Contractor's sole responsibility to adopt appropriate nominal mix proportions to yield the specified strength.

(b) Batching & Mixing of Concrete

Based on the adopted nominal mixes, aggregates shall be measured by volume. However cement shall be by weight only, using whole bags of cement.

4.8 Formwork

Formwork shall be all inclusive and shall consist of but not be limited to shores, bracings, sides of footings, walls, beams and columns, bottom of slabs etc. including ties, anchors, hangers, inserts, falsework, wedges etc.

The design and engineering of the formwork as well as its construction shall be the responsibility of the Contractor. However, if so desired by the Engineer, the drawings and calculations for the design of the formwork shall be submitted to the Engineer for approval.

Formwork shall be designed to fulfill the following requirements:

(a) Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.
(b) Made of suitable materials.
(c) Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits.
(d) Capable of withstanding without deflection the worst combination of selfweight, reinforcement and concrete weight, all loads and dynamic effects arising from construction and compacting activities, wind and weather forces.
(e) Capable of easily striking without shock, disturbance or damage to the concrete.
(f) Soffit forms capable of imparting a camber if required.
(g) Soffit forms and supports capable of being left in position if required.
(h) Capable of being cleaned and/or coated if necessary immediately prior to casting the concrete; design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

The formwork may be of timber, plywood, steel, plastic or concrete depending upon the type of finish specified. Sliding forms and slip form may be used with the approval of the Engineer. Timber for formwork shall be well seasoned, free from sap, shakes, loose knots, worm holes, warps and other surface defects. Joints between formwork and structures shall be sufficiently tight to prevent loss of slurry from concrete, using seals if necessary.

The faces of formwork coming in contact with concrete shall be cleaned and two coats of approved mould oil applied before placing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces dust etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

Forms intended for reuse shall be treated with care. Forms that have deteriorated shall not be used. Before reuse, all forms shall be thoroughly scraped, cleaned, nails removed, holes suitably plugged, joints repaired and warped lumber replaced to the satisfaction of the Engineer. The Contractor shall equip himself with enough shuttering to allow for wastage so as to complete the job in time.

Permanent formwork shall be checked for its durability and compatibility with adjoining concrete before it is used in the structure. It shall be properly anchored to the concrete.

Wire ties passing through beams, columns and walls shall not be allowed. In their place bolts passing through sleeves shall be used. Formwork spacers left insitu shall not impair the desired appearance or durability of the structure by causing spalling, rust staining or allowing the passage of moisture.

For liquid retaining structures, sleeves shall not be provided for through bolts nor shall through bolts be removed if provided. The bolts, in the latter case, shall be cut at 25 mm depth from the surface and the hole made good by cement mortar of the same proportion as the concrete just after striking the formwork.

All corners and angles exposed in the finished structure shall have chamfers or fillets of 20 mm x 20 mm size, except where specified in the drawings.

Forms for substructure may be omitted when, in the opinion of the Engineer, the open excavation is firm enough (in hard non-porous soils) to act as a form. Such excavations shall be larger, as approved by the Engineer, than that required as per drawing to compensate for irregularities in excavation.

The Contractor shall provide adequate props carried down to a firm bearing without overloading any of the structures.

The shuttering for beams and slabs shall be so erected that the side shuttering of beams can be removed without disturbing the bottom shuttering. If the shuttering for a column is erected for the full height of the column, one side shall be built up in sections as placing of concrete proceeds or windows left for placing concrete from the side to limit the drop of concrete to 1.0m or as approved by the Engineer. The Contractor shall temporarily and securely fix items to be cast (embedments/ inserts) in a manner that will not hinder the striking of forms or permit loss of grout.

Formwork showing excessive distortion, during any stage of construction, shall be repositioned and strengthened. Placed concrete affected by faulty formwork, shall be entirely removed and formwork corrected prior to placement of new concrete at Contractor's cost.

The striking time for formwork shall be determined based on the following requirements :

(a) Development of adequate concrete strength;
(b) Permissible deflection at time of striking form work;
(c) Curing procedure employed - its efficiency and effectiveness;
(d) Subsequent surface treatment to be done;
(e) Prevention of thermal cracking at re-entrant angles;
(f) Ambient temperatures; and
(g) Aggressiveness of the environment (unless immediate adequate steps are taken to prevent damage to the concrete).

Under normal circumstances (generally where temperatures are above 20^{o}C) forms may be struck after expiry of the time period given in IS:456 unless approved otherwise by the Engineer. For Portland Pozzolana/slag cement the stripping time shall be suitably modified as approved by the Engineer. It is the Contractor's responsibility to ensure that forms are not struck until the concrete has developed sufficient strength to support itself, does not undergo excessive deformation and resist surface damage and any stresses arising during the construction period.

4.9 Reinforcement Workmanship

Reinforcing bars supplied bent or in coils shall be straightened cold without damage. No bending shall be done when ambient temperature is below 5°C. Local warming may be permitted if steel is kept below 100° C.

All bars shall be accurately bent gradually and according to the sizes and shapes shown on the drawings/ schedules or as directed by the Engineer.

Re-bending or straightening incorrectly bent bars shall not be done without the approval of the Engineer.

Reinforcement shall be accurately fixed and maintained firmly in the correct position by the use of blocks, spacers, chairs, binding wire etc. to prevent displacement during placing and compaction of concrete. The tied in place reinforcement shall be approved by the Engineer prior to concrete placement. Spacers shall be of such materials and designs as will be durable, not lead to corrosion of the reinforcement and not cause spalling of the concrete cover.

Binding wire shall be 16 gauge soft annealed wire. Ends of the binding wire shall be bent away from the concrete surface and in no case encroach into the concrete cover.

Substitution of reinforcement, laps/splices not shown on drawing shall be subject to Engineer's approval.

4.10 Tolerances

Tolerance is a specified permissible variation from lines, grade or dimensions given in drawings. No tolerance specified for horizontal or vertical building lines or footings shall be construed to permit encroachment beyond the legal boundaries. Tolerance for formed and concrete dimensions shall be as per IS:456 unless specified otherwise.

4.10.1 Tolerances for R.C. Buildings

(a) Variation from the Plumb

(i) In the lines and surfaces of columns, piers, walls and in arises 5 mm per 2.5 m or 25 mm, whichever is less.

(ii) For exposed corner columns and other conspicuous lines

In any bay or 5 m maximum	-	5 mm
In 10 m or more	-	10 mm

(b) Variation from the level or from the grades indicated on the drawings

(i) In slab soffits, ceilings, beam soffits, and in arises

In 2.5 m	-	5 mm
In any bay or 5 m maximum	-	10 mm
In 10 m or more	-	15 mm

(ii) For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines :

In any bay or 5 m maximum	-	5 mm
In 10 m or more	-	10 mm

(c) Variation of the linear building lines from established position in plan and related position of columns, wall and partitions:

In any bay or 5 m maximum	-	10 mm
In 10 m or more	-	20 mm

(d) Variation in the sizes and locations of sleeves, openings in walls and floors – 5 mm except in the case of and for anchor bolts.

(e) Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls

Minus	-	5 mm
Plus	-	10 mm

(f) Footings

(i) Variation in dimension in plan

Minus	-	5 mm
Plus	-	50 mm

(ii) Misplacement or eccentricity
2% of footing width in the direction of misplacement but not more than 50 mm

(iii) Reduction in thickness

Minus	-	5% of specified thickness subject to a maximum of 50 mm

(g) Variation in Steps

(i) In a flight of stairs

Rise	-	3 mm
Tread	-	5 mm

(ii) In consecutive steps

Rise	-	1.5 mm
Tread	-	3.0 mm

4.10.2 Tolerances in other structures

(a) All structures

(i) Variation of the construction linear outline from established position in plan

In 5 m	-	10 mm
In 10 m or more	-	15 mm

(ii) Variations of dimensions to individual structure features from established positions

In 20 m or more	-	25 mm
In buried construction	-	50 mm

(iii) Variation from plumb, from specified batter or from curved surfaces of all structures

In 2.5 m	-	10 mm
In 5 m	-	15 mm
In 10 m or more	-	25 mm
In buried construction	-	Twice the above amounts

(iv) Variation from level or grade indicated on drawings in slab, beams, soffits, horizontal grooves and visible arises.

In 2.5 m	-	5 mm
In 7.5 m or more	-	10 mm
In buried construction	-	Twice the above amounts

(v) Variation in cross-sectional dimensions of columns, beams, buttresses, piers and similar members

Minus	-	5 mm
Plus	-	10 mm

(vi) Variation in the thickness of slabs, walls, arch sections and similar members

Minus	-	5 mm
Plus	-	10 mm

(b) **Footing for columns, piers, walls, buttresses and similar members**

(i) Variation of dimension in plan

Minus	-	10 mm
Plus	-	50 mm

(ii) Misplacement or eccentricity
2% footing width in the direction of misplacement but not more than 50 mm

(iii) Reduction in thickness
5% of specified thickness subject to a maximum of 50 mm.

Tolerance in fixing anchor bolts shall be as follows:

(i) Anchor bolts without sleeves	-	1.5 mm in plan
(ii) Anchor bolts with sleeves	-	5.0 mm in elevation
for bolts upto and including 28 mm dia	-	5 mm in all directions
for bolts 32 mm dia and above	-	3 mm in all directions
(iii) Embedded parts	-	5 mm in all directions

4.10.3 Tolerances in Formwork:

The formwork shall be designed and constructed to the shapes, lines and dimensions shown on the drawings within the tolerances given below:

(i)	Deviation from specified dimensions of cross section of columns and beams	- 6 mm + 12 mm
(ii)	Deviations from dimensions of footings (Tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel or dowels)	
	- Dimension in plan	- 12 mm + 50 mm
	- Eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50 mm
	- Thickness	± 0.05 times the specified thickness

4.11 Preparation Prior to Concrete Placement

Before concrete is actually placed in position, the inside of the formwork shall be cleaned and mould oil applied, inserts and reinforcement shall be correctly positioned and securely held, necessary openings, pockets, etc. provided.

All arrangements-formwork, equipment and proposed procedure, shall be approved by the Engineer. Contractor shall maintain separate Pour Card for each pour as per the format enclosed.

4.12 Transporting, Placing and Compacting Concrete

Concrete shall be transported from the mixing plant to the formwork with minimum time lapse by methods that shall maintain the required workability and will prevent segregation, loss of any ingredients or ingress of foreign matter or water.

In all cases concrete shall be deposited as nearly as practicable directly in its final position. To avoid segregation, concrete shall not be rehandled or caused to flow. For locations where direct placement is not possible and in narrow forms the Contractor shall provide suitable drops and "Elephant Trunks". Concrete shall not be dropped from a height of more than 1.0m as stipulated in clause 4.8.

Concrete shall not be placed in flowing water. Under water, concrete shall be placed in position by tremies or by pipeline from the mixer and shall never be allowed to fall freely through the water. While placing concrete the Contractor shall proceed as specified below and also ensure the following:

(a) Continuously between construction joints and pre- determined abutments.
(b) Without disturbance to forms or reinforcement.
(c) Without disturbance to pipes, ducts, fixings and the like to be cast in; ensure that such items are securely fixed. Ensure that concrete cannot enter open ends of pipes and conduits etc.
(d) Without dropping in a manner that could cause segregation or shock.
(e) In deep pours only when the concrete and formwork designed for this purpose and by using suitable chutes or pipes.
(f) Do not place if the workability is such that full compaction cannot be achieved.
(g) Without disturbing the unsupported sides of excavations; prevent contamination of concrete with earth. Provide sheeting if necessary. In supported excavations, withdraw the linings progressively as concrete is placed.
(h) If placed directly onto hardcore or any other porous material, dampen the surface to reduce loss of water from the concrete.
(i) Ensure that there is no damage or displacement to sheet membranes.
(j) Record the time and location of placing structural concrete.

Concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer. Concrete shall be compacted during placing with approved vibrating equipment without causing segregation until it forms a solid mass free from voids thoroughly worked around reinforcement and embedded fixtures and into all corners of the formwork. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn slowly till air bubbles cease to come to the surface, leaving no voids. When placing concrete in layers advancing horizontally, care shall be taken to ensure adequate vibration, blending and melding of the concrete between successive layers. Vibrators shall not be allowed to come in contact with reinforcement, formwork and finished surfaces after start of initial set

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Concrete may be conveyed and placed by mechanically operated equipment after getting the complete procedure approved by the Engineer. The slump shall be held to the minimum necessary for conveying concrete by this method. When concrete is to be pumped, the concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

Except when placing with slip forms, each placement of concrete in multiple lift work shall be allowed to set for at least 24 hours after the final set of concrete before the start of subsequent placement. Placing shall stop when concrete reaches the top of the opening in walls or bottom surface of slab, in slab and beam construction, and it shall be resumed before concrete takes initial set but not until it has had time to settle as approved by the Engineer. Concrete shall be protected against damage until final acceptance.

4.13 Mass Concrete Works

Sequence of pouring for mass concrete works shall be as approved by the Engineer. The Contractor shall exercise great care to prevent shrinkage cracks and shall monitor the temperature of the placed concrete if directed.

4.14 Curing

Curing and protection shall start immediately after the compaction of the concrete to protect it from:

(a) Premature drying out, particularly by solar radiation and wind;
(b) leaching out by rain and flowing water;
(c) rapid cooling during the first few days after placing;
(d) high internal thermal gradients;
(e) low temperature or frost;
(f) vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

All concrete, unless approved otherwise by the Engineer, shall be cured by use of continuous sprays or ponded water or continuously saturated coverings of sacking, canvas, hessian or other absorbent material for the period of complete hydration with a minimum of 7 days. The quality of curing water shall be the same as that used for mixing.

Where a curing membrane is approved to be used by the Engineer, the same shall be of a non-wax base and shall not impair the concrete finish in any manner. The curing compound to be used shall be approved by the Engineer before use and shall be applied with spraying equipment capable of a smooth, even textured coat.

Curing may also be done by covering the surface with an impermeable material such as polyethylene, which shall be well sealed and fastened.

4.15 Construction Joints and Keys

Construction joints will be as shown on the drawing or as approved by the Engineer. Concrete shall be placed without interruption until completion of work between construction joints. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made with the approval of the Engineer.

Dowels for concrete work, not likely to be taken up in the near future, shall be coated with cement slurry and encased in lean concrete as indicated on the drawings or as approved by the Engineer.

As soon as the exposed concrete has sufficiently hardened, the surface of the joint shall be water jetted or brushed with a stiff brush to expose the larger aggregate without being disturbed. Roughening of the surface by chipping or hacking will not generally be approved. Before placing fresh concrete against a

construction joint all loose material shall be removed and the surface sluiced with water until it is perfectly clean, thereafter all ponded water should be removed.

When concreting is to be resumed on a surface which has not fully hardened, all laitance shall be removed by wire brushing, the surface wetted, free water removed and a coat of cement slurry applied. On this, a layer of concrete not exceeding 150 mm thickness shall be placed and well rammed against the old work. Thereafter work shall proceed in the normal way.

4.16 Foundation Bedding

All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or spongy areas shall be cleaned out and back filled with either soil-cement mixture, lean concrete or clean sand compacted as approved by the Engineer. The surfaces of absorptive soils shall be moistened.

Concrete shall not be deposited on large sloping rock surfaces. The rock shall be cut to form rough steps or benches by picking, barring or wedging. The rock surface shall be kept wet for 2 to 4 hours before concreting.

4.17 Finishes

4.17.1 General

The formwork for concrete works shall be such as to give the finish as specified. The Contractor shall make good any unavoidable defects as approved consistent with the type of concrete and finish specified; defects due to bad workmanship (e.g. damaged or misaligned forms, defective or poorly compacted concrete) will not be accepted. The Contractor shall construct the formwork using the correct materials and to meet the requirements of the design and to produce finished concrete to required dimensions, plumbs, planes and finishes.

4.17.2 Surface Finish Type F1

The main requirement is that of dense, well compacted concrete. No treatment is required except repair of defective areas, filling all form tie holes and cleaning up of loose or adhering debris. For surfaces below grade which will receive waterproofing treatment the concrete shall be free of surface irregularities which would interfere with proper and effective application of waterproofing material specified for use.

4.17.3 Surface Finish Type F2

The appearance shall be that of a smooth dense, well- compacted concrete showing the slight marks of well fitted shuttering joints. The Contractor shall make good any blemishes.

4.17.4 Surface Finish Type F3

This finish shall give an appearance of smooth, dense, well-compacted concrete with no shutter marks, stain free and with no discolouration, blemishes, arises, airholes etc. Only lined or coated plywood with very tight joints shall be used to achieve this finish. The panel size shall be uniform and as large as practicable. Any minor blemishes that might occur shall be made good by the Contractor.

4.17.5 Unformed Surfaces

Finishes to unformed surfaces of concrete shall be classified as U1, U2, U3, 'spaded' or 'bonded' concrete. Where the class of finish is not specified the concrete shall be finished to Class U1.

Class U1 finish is the first stage for Class U2 and U3 finishes and for a bonded concrete surface. Class U1 finish shall be a levelled and screeded, uniform plain or ridged finish which (unless it is being converted to Class U2, U3, or bonded concrete) shall not be disturbed in any way after the initial set and during the period of curing, surplus concrete being struck off immediately after compaction.

Where a bonded concrete surface is specified, the laitance shall be removed from the Class U1 finished surface and the aggregate exposed while the concrete is still green.
A spaded finish shall be a surface free from voids and brought to a reasonably uniform appearance by the use of shovels as it is placed in the Works.

Class U2 finish shall be a wood float finish. Floating shall be done after the initial set of the concrete has taken place and the surface has hardened sufficiently. The concrete shall be worked no more than is necessary to produce a uniform surface free from screed marks.

Class U3 finish shall be a hard smooth steel-trowelled finish. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked into the surface. The surfaces shall be trowelled under firm pressure and left free from trowel marks.

The addition of dry cement, mortar or water shall not be permitted during any of the above operations.

4.17.6 Integral Cement Finish on Concrete Floor

In all cases where integral cement finish on a concrete floor has been specified, the top layer of concrete shall be screeded off to proper level and tamped with tamper so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface. Where specified, a floor hardener as approved by the Engineer shall be supplied and used as recommended by the manufacturer.

4.18 Repair and Replacement of Unsatisfactory Concrete

Immediately after the shuttering is removed, all the defective areas such as honey-combed surfaces, rough patches, holes left by form bolts etc. shall be inspected by the Engineer who may permit patching of the defective areas or reject the concrete work.

All through holes for shuttering shall be filled for full depth and neatly plugged flush with surface.

Rejected concrete shall be removed and replaced by the Contractor at no additional cost to the Employer.

For patching of defective areas all loose materials shall be removed and the surface shall be prepared as approved by the Engineer.

Bonding between hardened and fresh concrete shall be done either by placing cement mortar with approved bonding agent or by applying epoxy. The decision of the Engineer as to the method of repairs to be adopted shall be final and binding on the Contractor. The surface shall be saturated with water for 24 hours before patching is done with 1:5 cement sand mortar. The use of epoxy for bonding fresh concrete shall be carried out as approved by the Engineer.

All the form bolt repairs and delayed repairs shall be carried out using a proportion of white cement in repair mix to the approval of the Engineer, so as to match the colour of the surrounding area.

4.19 Vacuum Dewatering of Slabs

Where specified floor slabs, either grade or suspended, shall be finished by vacuum dewatering including all operations such as poker vibration, surface vibration, vacuum processing, floating and trowelling as per equipment manufacturers recommendation. The equipment to be used shall be subject to the Engineer's approval.

4.20 Hot Weather Requirements

Concreting during hot weather shall be carried out as per IS:7861 (Part I).

Adequate provisions shall be made to lower concrete temperatures which shall not exceed 33^{o} C at the time of placement of fresh concrete.

Where directed by the Engineer, the Contractor shall spray non-wax based curing compound on unformed concrete surfaces at no extra costs.

4.21 Liquid Retaining Structures

The Contractor shall take special care for concrete for liquid retaining structures, underground structures and those others specifically called for to guarantee the finish and water tightness.

The minimum level of surface finish for liquid retaining structures shall be Type F2. All such structures shall be hydro-tested.

The Contractor shall make all arrangements for hydro-testing of structure, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipe lines etc.

Any temporary arrangements that may have to be made to ensure stability of the structures shall also be considered to have been taken into account while quoting the rates.

Any leakage that may occur during the hydro-test or subsequently during the defects liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/epoxy pressure grouting, guniting or such other methods as may be approved by the Engineer. All such rectification shall be done by the Contractor to the entire satisfaction of the Employer/Engineer at no extra cost to the Employer.

4.22 Testing Concrete Structures for Leakage

Hydro-static test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by the Engineer, as described below:

In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven day period for absorption after filling with water.

In the case of structures whose external faces are buried and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded

again at subsequent intervals of 24 hours over a period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the water tightness of the structure. The Engineer shall decide on the actual permissible nature of this drop in the surface level, taking into account whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Each compartment/segment of the structure shall be tested individually.
For structures such as pipes, tunnels etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

4.23 Optional Tests

If the Engineer is not satisfied with the results of the tests under Clause 4.5 or otherwise considers that the materials i.e. cement, sand, coarse aggregates, reinforcement and water are not in accordance with the Specifications or if specified concrete strengths are not obtained, he may order tests to be carried out on these materials in laboratory, to be approved by the Engineer, as per relevant IS Codes. Contractor shall have to pay for these tests.

In the event of any work being suspected of faulty material or workmanship requiring its removal or if the works cubes do not give the stipulated strengths, the Engineer reserves the right to order the Contractor to take out cores and conduct tests on them or do ultrasonic testing or load testing of structure, etc. The Engineer also reserves the right to ask the Contractor to dismantle and re-do such unacceptable work, at no cost to the Employer.

If the structure is certified as failed by Engineer, the cost of the test and subsequent dismantling/reconstruction shall be borne by the Contractor.

The quoted unit rates/prices of concrete shall be deemed to provide for all tests mentioned above.

4.24 Grouting

4.24.1 Standard Grout

Grout shall be provided as specified on the drawings. The proportion of Standard Grout shall be such as to produce a flow able mixture consistent with minimum water content and shrinkage. Surfaces to be grouted shall be thoroughly roughened and cleaned. All Structural steel elements to be grouted shall be cleaned of oil, grease, dirt etc. The use of hot, strong caustic solution for this purpose will be

permitted. Prior to grouting, the hardened concrete shall be saturated with water and just before grouting water in all pockets shall be removed. Grouting once started shall be done quickly and continuously. Variation in grout mixes and procedures shall be permitted if approved by Engineer. The grout proportions shall be limited as follows:

Use	Grout Thickness	Mix Proportions	W/C Ratio (max)
a) Fluid mix	Under 25mm	One part Portland Cement to one part sand	0.44
b) General mix	25mm and over but less than 50mm	One part Portland Cement to 2 parts of sand	0.53
c) Stiff mix	50mm and over	One part Portland Cement to 3 parts of sand	0.53

4.24.2 Non-Shrink Grout

Non – shrink grout where required shall be provided in strict accordance with the manufacturer's instructions / specifications on the drawings.

4.25 Inspection

All materials, workmanship and finished construction shall be subject to continuous inspection and approval of Engineer. Materials rejected by Engineer shall be expressly removed from site and shall be replaced by Contractor immediately.

4.26 Clean-Up

Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris, scraps of wood, etc. resulting from the work shall be removed and the premises left clean.

4.27 Acceptance Criteria

Any concrete work shall satisfy the requirements given below individually and collectively for it to be acceptable.

a) Properties of constituent materials;
b) Characteristic compressive strength;
c) specified mix proportions;
d) Minimum cement content;
e) Maximum free-water/cement ratio;
f) Workability;
g) Temperature of fresh concrete;
h) Density of fully compacted concrete;
i) cover to embedded steel;
j) Curing;

k) Tolerances in dimensions;
l) Tolerances in levels;
m) Durability;
n) Surface finishes;
o) Special requirements such as;
   i) Water tightness
   ii) Resistance to aggressive chemicals
   iii) Resistance to freezing and thawing
   iv) Very high strength
   v) Improved fire resistance
   vi) Wear resistance
   vii) Resistance to early thermal cracking

The Engineer's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the Contractor.

For work not accepted, the Engineer may review and decide whether remedial measures are feasible so as to render the work acceptable. The Engineer shall in that case direct the Contractor to undertake and execute the remedial measures. These shall be expeditiously and effectively implemented by the Contractor. Nothing extra shall become payable to the Contractor by the Employer for executing the remedial measures.

4.28 Mode of Measurement and Payment

The unit rate for concrete work under various categories shall be all inclusive and no claims for extra payment on account of such items as leaving holes, embedding inserts, etc. shall be entertained unless separately provided for in the Schedule of Quantities. No extra claim shall also be entertained due to change in the number, position and/or dimensions of holes, slots or openings, sleeves, inserts or on account of any increased lift, lead of scaffolding etc. All these factors should be taken into consideration while quoting the unit rates. Unless provided for in the Schedule of Quantities the rates shall also include fixing inserts in all concrete work, whenever required.

Payments for concrete will be made on the basis of unit rates quoted for the respective items in the Schedule of Quantities. No deduction in the concrete quantity will be made for reinforcements, inserts etc. and opening less than 0.100 of a sq.m. and 0.010 cu.m where concrete is measured in cu. metres. Where no such deduction for concrete is made, payment for shuttering work provided for such holes, pockets, etc. will not be made. Similarly the unit rates for concrete work shall be inclusive or exclusive of shuttering as provided for in the Schedule of Quantities.

Payment for beams will be made for the quantity based on the depth being reckoned from the underside of the slabs and length measured as the clear distance between supports. Payment for columns shall be made for the quantity based on height reckoned upto the underside of slabs/beams.

The unit rate for precast concrete members shall include formwork, mouldings, finishing, hoisting and setting in position including setting mortar, provision of lifting arrangement etc. complete. Reinforcement and inserts shall be measured and paid for separately under respective item rates.

Only the actual quantity of steel embedded in concrete including laps as shown on drawings or as approved by Engineer shall be measured and paid for, irrespective of the level or height at which the

work is done. The unit rate for reinforcement shall include all wastages, binding wires, chairs, spacer bars etc. for which no separate payment shall be made.

Where the formwork is paid for separately, it shall be very clearly understood the payment for formwork is inclusive of formwork, shuttering, shoring, propping scaffolding etc. Only the net area of concrete formed (shuttered) shall be measured for payment.

4.29 Waterstops

4.29.1 Material

The material for the PVC waterstops shall be a plastic compound with the basic resin of polyvinyl chloride and additional resins, plasticizers, inhibitors, which satisfies the performance characteristics specified below as per IS:12200. Testing shall be in accordance with IS: 8543.

a)	Tensile strength	11.6 N/mm^2 minimum
b)	Ultimate elongation	300% minimum
c)	Tear resistance	4.9 N/mm^2 minimum
d)	Stiffness in flexure	2.46 N/mm^2 minimum
e)	Accelerated extraction	
i)	Tensile strength	10.50 N/mm^2 minimum
ii)	Ultimate elongation	250% minimum
(f)	Effect of Alkali	7 days
i)	Weight increase	0.10% maximum
ii)	Weight decrease	0.10% maximum
iii)	Hardness change	± 5 points
(g)	Effect of Alkali	28 days
i)	Weight increase	0.40% maximum
ii)	Weight decrease	0.30% maximum
iii)	Dimension change	±1%

PVC water stops shall be either of the bar type, serrated with centre bulb and end grips for use within the concrete elements or of the surface (kicker) type for external use.

PVC water stops shall be of approved manufacture. Samples and the test certificate shall be got approved by the Engineer before procurement for incorporation in the works.

4.29.2 Workmanship

Waterstops shall be cleaned before placing them in position. Oil or grease shall be removed thoroughly using water and suitable detergents.

Waterstops shall be procured in long lengths as manufactured to avoid joints as far as possible. Standard L or T type of intersection pieces shall be procured for use depending on their requirement. Any non-standard junctions shall be made by cutting the pieces to profile for jointing. Lapping of waterstops shall not be permitted. All jointing shall be of fusion welded type as per manufacturer's instructions.

Waterstops shall be placed at the correct location/level and suitably supported at intervals with the reinforcement to ensure that it does not deviate from its intended position during concreting and vibrating. Particular care shall also be taken to ensure that no honey-combing occurs because of the serrations/end grips. Projecting portions of the waterstops embedded in concrete shall be thoroughly cleaned of all mortar/ concrete coating before resuming further concreting operations. The projecting waterstop shall also be suitably supported at intervals with the reinforcement to maintain its intended position during concreting so as to ensure that it does not bend leading to formation of pockets.

4.29.3 Measurement

Measurement shall be in running metres correct to two places of decimal. No separate payment shall be made for joints or intersection pieces.

4.30 Preformed Fillers and Joint Sealing Compound

4.30.1 Materials

Preformed filler for expansion/isolation joints shall be non-extruding and resilient type of bitumen impregnated fibers conforming to IS:1838 (Part I) or equivalent.

Bitumen coat to concrete/masonry surfaces for fixing the preformed bitumen filler strip shall conform to IS:702. Bitumen primer shall conform to IS: 3384.

Sealants shall be of the following types:

(a) Sealant Type A

Sealant Type A shall be a gun grade, non-slumping compound suitable for sealing horizontal, vertical and soffit joints in water retaining structures. It shall be a UK WFBS material approved for unrestricted use in contact with potable water to the full exposure condition of 15,000 mm^2/l, and shall not support bacterial growth.

It shall be stable and shall have a low water absorption and good adhesion to concrete.

Hardness (Shore A)	:	> 12
Transverse Movement Accommodation	:	±15%

(b) Sealant Type B

Sealant type shall be a gun grade compound, suitable for sealing vertical movement and construction joints in concrete structures. It shall be flexible, resistant to aging, physical damage and weathering and shall have good adhesion to concrete.

Hardness (Shore A)	:	> 12
Transverse Movement Accommodation	:	±12.5%

(c) Sealant Type C

Sealant type C shall be similar to Type B above. In addition it shall have been designed for sealing movement and construction joints in hydraulic and water retaining structures and shall be suitable for use in contact with potable water.

Hardness (Shore A) : > 20
Transverse Movement Accommodation : ±12.5%

(d) Sealant Type D

Sealant Type D shall be a pourable compound suitable for sealing horizontal movement and construction joints in concrete structures. It shall be flexible, resistant to aging, physical damage and weathering and shall have good adhesion to concrete.

Hardness (Shore A) : > 9

Transverse Movement Accommodation : ±12.5%

(e) Sealant Type E

Sealant Type E shall be a cold pouring compound complying with BS 5212, suitable for sealing movement and construction joints in concrete paved areas. It shall be resistant to fuels, oils and hydraulic fluids. It shall be tough, abrasion-resistant and shall not decompose in strong sunlight.

Hardness (Shore A) : > 12
Transverse Movement Accommodation : ±12.5%

(f) Approved Sealants

The following approved sealants meet the above specifications.

Sealant Type A, B and C	:	Thioflex 600 gun grade
Sealant Type D	:	Thioflex 600 pourable grade
Sealant Type E	:	Colpor 200

The hardness value specified in the above summaries is the Shore A Durometer value at 14 days at 25^{o} C and 50% RH. The specified transverse movement values are based on joints having a width to depth ratio of 1.5: 1.

The Contractor may use the above sealants or ones meeting equivalent or higher specifications.

4.30.2 Workmanship

The thickness of the preformed bitumen filler shall be 25mm for expansion joints and 50mm for isolation joints around foundation supporting rotatory equipments. Contractor shall procure the strips of the desired thickness and width in lengths as manufactured. Assembly of small pieces/thicknesses of strips to make up the specified size shall not be permitted.

The concrete/masonry surface shall be cleaned free from dust and any loose particles. When the surface is dry, one coat of industrial blown type bitumen of grade 85/25 conforming to IS:702 shall be applied hot by brushing at the rate of 1.20 kg/sq.m. When the bitumen is still hot the preformed bitumen filler shall be

pressed and held in position till it completely adheres. The surface of the filler against which further concreting/masonry work is to be done shall similarly be applied with one coat of hot bitumen at the rate of 1.20 kg/sq.m.

Sealing compound shall be heated to a pouring consistency for enabling it to run molten in a uniform manner into the joint. Before pouring the sealing compound, the vertical faces of the concrete joint shall be applied hot with a coat of bitumen primer conforming to IS:3384 in order to improve the adhesive quality of the sealing compound.

Expansion joints between beams/slabs shall be provided with 100mm wide x 4mm thick mild steel plate at the soffit of RCC beams/slabs to support and prevent the preformed joint filler from dislodging. This plate shall be welded to an edge angle of ISA 50 x 50 x 6mm provided at the bottom corner, adjacent to the expansion joint of one of the beams/slabs, by intermittent fillet welding. Steel surfaces shall be provided with 2 coats of red oxide zinc chrome primer and 3 coats of synthetic enamel paint finish.

The Contractor shall construct recesses at all joints and on both faces of the concrete work except on the underside of ground slabs. The recesses shall be accurately formed to the lines and dimensions shown on the Drawings or as agreed with the Engineer.

The Contractor shall prepare the surfaces of the recess and shall supply a joint sealer and fill or caulk the recess completely with it.

Joint sealing shall not be commenced without the approval of the Engineer. In reservoir joints the sealer shall be poured after completion of the water tightness test, to the satisfaction of the Engineer.

All joint sealers shall be from an approved manufacturer. The Contractor shall supply the manufacturer's test certificates for each consignment of each type of joint sealant delivered to the Site and shall if requested supply to the Engineer sufficient samples of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate test procedure.

Sealants shall be installed in strict accordance with the manufacturer's instructions. De-bonding strip shall be used in conjunction with the sealers as indicated on the Drawings. The de-bonding strip shall be compatible with the joint sealer and shall be resistant to attach from the primer used to bond the sealer to the concrete.

Polysulphide and polyurethane sealants shall not abut bitumen sealers. Surfaces to receive Polysulphide and polyurethane sealants shall be kept free from bituminous paints. All sealants shall be appropriate for the prevailing climatic conditions. Bituminous sealants shall comply with the BS 2499 for Type A1. Polysulphide sealants shall comply with IS 12118.

4.30.3 Measurement

Measurement for the preformed joint filler shall be in sq.m correct to two places of decimal for the specified thickness as per items of work. Measurement for applying the bitumen coat to concrete/masonry surfaces shall be in sq.m correct to two places of decimal. Measurement for the joint sealing compound shall be in running metres correct to two places of decimal for the specified width and thickness as per the items of work. Measurement for the mild steel corner angle and plate shall be by weight as per the items of work.

4.31 Concreting Records

A written record of the concrete works shall be made each day by the Contractor and kept available for inspection by the Engineer. The diary shall contain notes and records of :

(a) The names of the Contractor's Engineer who are responsible for the different phases of the concrete work and also the names of their assistants.

(b) The temperatures of air, water, cement, aggregates, together with the air humidity and type of weather.

(c) Deliveries to the Site of concrete materials (quantity, brand of concrete, etc).

(d) Inspections carried out, tests performed, etc. and their results.

(e) Times of commencement and completion of different parts of the concrete works and times of erection and striking of forms.

(f) Quantity of cement, fine and coarse aggregate and admixture used for each section of work and the number and kind of test samples taken on these ingredients and water.

CONCRETE POUR CARD

CLIENT : DATE : POUR NO. :

PROJECT : STRUCTURE :

Contractor : MAX. AGGREGATE SIZE / SLUMP :
START / COMPLETION TIME : /

DRG. NO. :

MIXING TIME :

CONCRETE GRADE / QUANTITY : /

SL. NO.	ITEM		Contractor's Rep. Sign	Engineer's Sign	Remarks
1.	BEFORE CONCRET I NG	CENTRELINES CHECKED			POUR AUTHORISED SITE ENGINEER
2.	FORMWORK AND STAGING CHECKED FOR ACCURACY, STRENGTH & FINISH				
3.	REINFORCEMENT CHECKED				
4.	COVER TO REINFORCEMENT CHECKED				
5.	VERIFIED TEST CERTIFICATE FOR CEMENT/STEEL		YES / NO	YES / NO	
6.	ADEQUACY OF MATERIALS / EQUIPMENT FOR POUR		YES / NO	YES / NO	
7.	EMBEDDED PART S	CIVIL			
	CHECKED	MECHANICAL			
	(LOCATION & PLUMB)	ELECTRICAL			
8.	SOFFIT(S) & POUR TOP(T) LEVELS CHECKED BEFORE (B) & AFTER (A) FORM REMOVAL (ONLY OF BEAMS OF OVER 10 M SPAN & IMPORTANT STRUCTURE LIKE T.G. ETC.)		S(B) T(B) S(A) T(A)		

9.	CONSTRUCTION JOINTS LOCATION & TIME (IF NOT AS PER DRAWING)		
10.	CEMENT CONSUMPTION IN KGS.		
11.	NUMBER OF CUBES AND IDENTIFICATION MARKS		
12.	TEST CUBE RESULTS (7 DAYS / 28 DAYS)		
13.	CONCRETE CONDITION ON FORM REMOVAL	V.GOOD/GOOD/FAIR/POOR	

SITE-IN-CHARGE

NOTES :

1. EACH ITEM TO BE CHECKED AND SIGNED BY THE RESPECTIVE ENGINEERS.
2. ITEMS 8 TO 13 (BOTH INCLUSIVE) TO BE FILLED ONLY BY ENGINEER.
3. EACH POUR TO HAVE SEPARATE CARDS, IN TRIPLICATE ONE EACH FOR CLIENT, CONSULTANT & SITE OFFICE.

UNDER REMARKS INDICATE DEVIATIONS FROM DWGS. & SPECIFICATIONS, CONGESTION IN REINFORCEMENT IF ANY, UNUSUAL OCCURENCES, SUCH AS FAILURE OF EQUIPMENTS, SINKING OF SUPPORTS / PROPS. HEAVY RAINS AFFECTING CONCRETING, POOR COMPACTION, IMPROPER CURING, OTHER DEFICIENCIES, OBSERVATIONS ETC.

End of Section 4

SECTION 5

ROADS AND DRAINS

SECTION 5
ROADS AND DRAINS

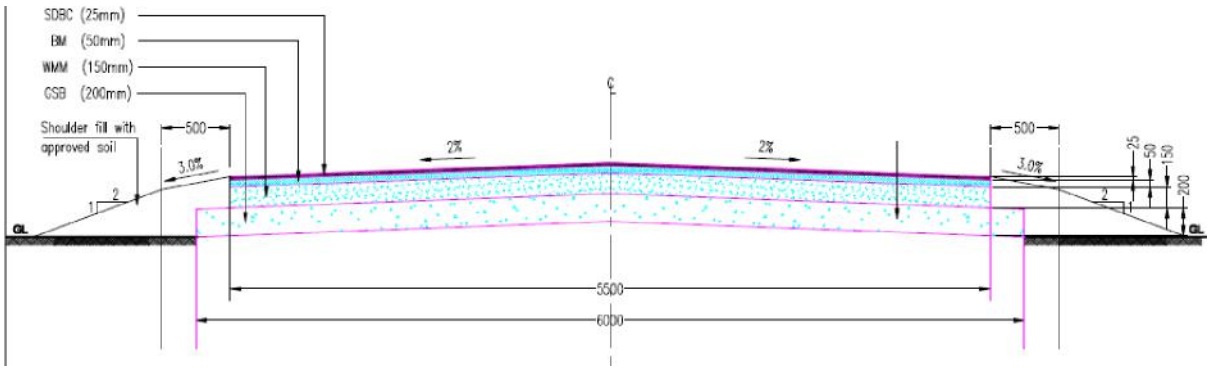
5.1 Definitions

The words like Contract, Contractor, Engineer (synonymous with Engineer-in-charge), Drawings, Employer, Government, Works and Work Site used in these Specifications shall be considered to have the meaning as understood from the definitions of these terms given in the General Conditions of Contract.

The following abbreviations shall have the meaning as set forth below:

MOSRTH : Ministry of Shipping, Road Transportation and Highways
IRC : Indian Roads Congress
IS : Indian Standard published by the Bureau of Indian "Standards
GSB : GRANULAR SUB BASE
WMM : WET MIX MACADAM
BM : BITUMINOUS MACADAM
BC : BITUMINOUS CONCRETE
CBR : California Bearing Ratio
AASHTO : American Association of State Highway and Transportation Officials
ASTM : American Society for Testing and Materials
BS : B ritish Standard published by the British Standards Institution

The various elements in the cross-section of a road referred to in these Specifications are shown in the cross-sections in **Fig. 5-1**.



TYPICAL CROSS SECTION FOR NEW ROAD FORMATION - STP AREA

Fig. 5-1: Proposed Typical Cross Section of Road in STP premise

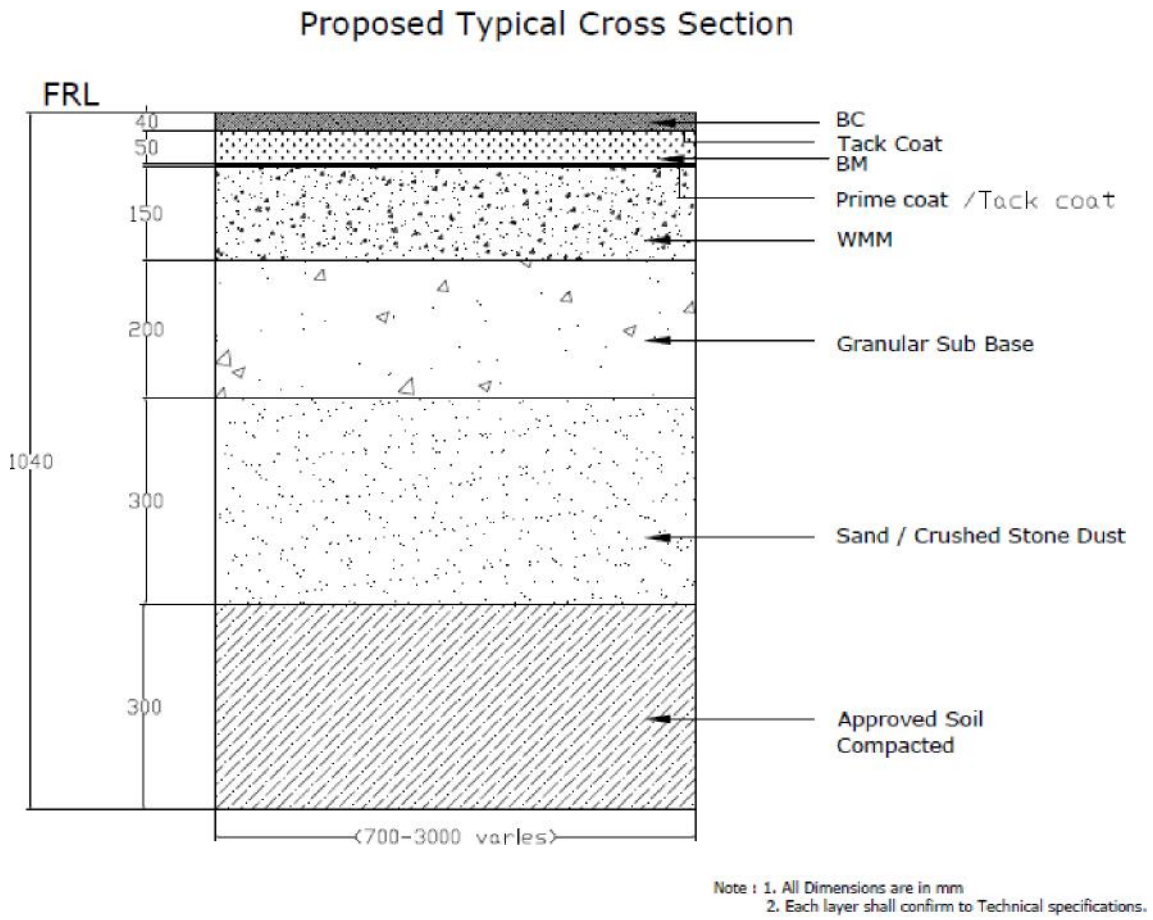


Fig. 5-2: Proposed Typical Cross Section of Road restoration for pipe trench

5.2 Applicable Codes and Specifications

The following specifications, standards and codes are referred to in this part.

IS : 460 (Parts 1 to 3) : Specification for Test sieves
IS : 1077 : Common burnt clay building bricks - Specification
IS : 1124 : Method of test for determination of water absorption, apparent specific gravity and porosity of natural building Aggregates / stones
IS : 1195 : Specification for Bitumen Mastic for Flooring
IS : 1196 : Code of Practice for Laying Bitumen Mastic Flooring
IS : 1834 : Specification for Hot Applied Sealing Compounds for Joints in Concrete
IS : 2386 (Parts 1 to 8) : Methods of test for aggregates for concrete
IS : 2720 (Part 5) : Method of Test for Soils for determination of Liquid and plastic limit.
IS : 6241 : Method of test for determination of stripping value of road aggregates.
IRC : 16 : Specification for priming of Base Course with Bituminous Primers.
IRC : 17 : Tentative specification for Single Coat Bituminous Surface Dressing
IRC : 19 : Standard specifications and code of practice for water bound macadam

IRC : 29 : Specification for bituminous concrete (Asphaltic Concrete) for road pavement.

MOSRTH
Specifications : Ministry of Shipping, Road transportation and Highways Specifications for Road and Bridge works
SECTION-101 : GENERAL
SECTION-301 : EARTHWORK
SECTION-401 : GRANULAR SUB BASE
SECTION-502 : WET MIX MACADAM
SECTION-504 : BITUMINOUS MACADAM
SECTION-509 : BITUMINOUS CONCRETE

5.3 Road configuration

The roads shall be installed in layers as per Drawing over the back fill as per concerned sections of MOSRTH. In STP premise the all the motorable road width is minimum 5.5m. On laying of Pumping main/sewer lines in the trenches, the roads shall be restored to its original condition in layers as per Drawing over the back fill as per concerned sections of MOSRTH

Technical specification:

a). Backfill over the water lines / sewer lines to the desired level as per drawing and specification.
b). Approved soil compacted in layers as per drawing, using soil deposited at site from road cutting and excavation to achieve compaction level Table 300-2 and Section 301 of MOSRTH Technical specification.
c). Layer of sand / stone dust as per drawing to achieve 97% relative compaction of laboratory dry density to meet requirement of table 300-2 of MOSRTH specification.
d). Granular Sub base as per section 401 of MOSRTH specification.
e). Wet mix macadam (WMM) as per section 502 of MOSRTH specification.
f). Bituminous macadam (BM) as per section 504 of MOSRTH specification.
g). Bituminous concrete (BC) as per section 509 of MOSRTH specification.

5.4 Materials

5.4.1 General

All materials shall be obtained from local sources and shall conform to technical specifications and be subject to Engineer's approval prior to use.

5.4.2 Approved soil for Subgrade / Embankment

The materials used in embankments, subgrades and miscellaneous backfills shall be soil, moorum, gravel, a mixture of these or any other material approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment/ subgrade.

It shall be ensured that the subgrade material when compacted to the density requirements as in **Table 5.1** (As per Table 300-2 of MOSRTH specification) shall yield the design CBR value of the subgrade.

Table 5.1: Compaction requirement for Subgrade
(As per Table 300-2 of MOSRTH Specification)

	Type of work/material	Relative compaction as % of max. lab dry density as per IS: 2720 (Part 8)
1	Subgrade and earthen shoulders	Not less than 97
2	Embankment	Not less than 95

The Contractor shall at least 7 working days before commencement of compaction submit the following to the Engineer for approval:

i) The values of Maximum Dry Density and Optimum Moisture Content obtained in accordance with IS: 2720 (Part 7) or (Part 8), as the case may be, appropriate for each of the fill materials he intends to use.

ii) A graph of density plotted against moisture content from which each of the values in (i) above of maximum dry density and optimum moisture content were determined.

iii) The Dry density-moisture content - CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part 7), heavy corresponding to IS: 2720 (Part 8) and intermediate in-between the two) for each of the fill materials he intends to use in the subgrade.

Once the above information has been approved by the Engineer, it shall form the basis for compaction.

5.4.3 Granular Sub base

The material to be used for the work shall be natural sand, murum, gravel, crushed stone, or combination thereof depending upon the grading required. Materials like crushed slag crushed concrete, brick metal and kankar may be allowed only with the specific approval of the Engineer. The material shall be free from organic or other deleterious constituents and conform to grading-iii given in **Table 5.2: Gradation for coarse graded granular Sub base.** (As per Table 400-2 of MOSRTH Specifications).

The CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions, which shall be taken as being the density relating to a uniform air, voids content of 5 per cent.

Table 5.2: Gradation for coarse graded granular Sub base.
(As per TABLE 400– 2 of MOSRTH Specification)

IS Sieve	Percent by weight passing the IS Sieve		
Designation	**Grading I**	**Grading II**	**Grading III**
75.0 mm	100	-	-
53.0 mm		100	
26.5 mm	55 - 75	50 - 80	100
9.50 mm			
4.75 mm	10-30	15-35	25-45
2.36 mm			
0.425 mm			
0.075 mm	<10	<10	<1

CBR Value(Minimum)	30	25	20

Note : The material passing 425 micron (0.425 mm) sieve for all the three gradings when tested according to IS : 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 per cent respectively.

5.4.4 Coarse Aggregates

Coarse aggregate, stone chippings shall consist of natural or crushed stone, clean, hard, tough, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt, salt, alkali, vegetable matter, adherent coatings, organic and other objectionable matter, and shall conform to the physical requirements given in **Table 5.3** and **Table 5.4** hereunder, as applicable. Aggregate for bituminous wearing courses shall in addition have good hydrophobic properties i.e. capacity of retaining the film of bituminous material applied to the stone in all weather conditions and especially in wet conditions. Basalt, dolerites are good in this respect; granite, quartzites are comparatively poor.

Table – 5.3: Physical Requirements of Coarse Aggregate for Wet Mix Macadam (WMM)

Sl. No	Test	Requirements	Test Method
1.	Los Angeles Abrasion Value* Or Aggregate Impact Value*	40 percent (max.) 30 percent (max.)	IS:2386 (Part – IV) IS:2386 (Part – IV) Or IS:5640***
2.	Flakiness Index **	15 percent (max.)	IS:2386 (Part I)

(*) Aggregate may satisfy requirements of either of two tests.

(**) Requirements of flakiness index shall be enforced only in case of crushed broken stone.

(***) Aggregates like brick, metal, kankar, laterite etc., which get softened in presence of water shall be tested for impact value under wet conditions in accordance with IS: 5640.

Table – 5.4: Physical Requirements of Aggregates for Bituminous macadam (BM)

Sl.No.	Test	Requirements	Test Method
1.	Los Angeles Abrasion Value* Or Aggregate Impact Value*	40 percent (max.) 30 percent (max.)	IS:2386 (Part – IV) IS:2386 (Part – IV)
2.	Flakiness Index **	35 percent (max.)	IS:2386 (Part I)
3.	Stripping Value	25 percent (max.)	IS:6241
4.	Water Absorption	2 percent (max.)	IS:2386 (Part-III)
5.	Soundness **Loss with Sodium Sulphate – 5 cycles** Loss with Magnesium Sulphate – 5 cycles	 12 percent (max.) 18 percent (max.)	IS:2386 (Part-V)

(*) Aggregate may satisfy requirements of either of two tests

(**) Requirement of flakiness index shall be enforced only in case of crushed broken stone

5.4.5 Murum/Kankar/Gravel

Murum shall contain low plasticity binder material mixed with hard granular particles such as sand and/or gravel. Murum shall be sound and hard of a quality not affected by weather, to be screened at the quarry and free from all impurities. Large lumps shall all be broken at the quarry and murum delivered at site must pass in every direction through a 63 mm ring. Murum shall not contain more than 5% to 8% of fines passing a 75 micron sieve.

Gravel shall be composed of large, coarse, silicious grains, sharp and gritty to the touch, thoroughly free from dirt, organic and deleterious matter. It shall be hard, tough, dense and shall not contain particles bigger than 12 mm and more than 10 percent silt.

5.4.6 Sand / Stone Dust

The sand / Stone dust shall consist of clean, hard, strong and durable pieces of crushed stone, crushed gravel, or a suitable combination of natural sand, crushed stone or gravel. They shall not contain dust, lumps, soft or flaky, materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Motorised sand washing machines should be used to remove impurities from sand. Fine aggregate having positive alkali-silica reaction shall not be used. All fine aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386, (Parts I to VIII). The Contractor shall submit to the Engineer the entire information indicated in Appendix A of IS: 383. The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5. The Sand used shall be coarse, sharp, gritty, clean, granular material. Only material passing through 4.75 mm sieve and retained on 75 micron sieve shall be used. The sand / Stone dust / fine aggregates shall conform to grading requirement in Table 5.5

Table 5.5 : Gradation requirement of Sand / Fine aggregates

(As per Table 1000-2 of MSORTH Specifications)

IS Sieve Size	Per cent by Weight Passing the Sieve		
	Zone I	Zone II	Zone III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

5.4.7 Bituminous Materials

Bituminous materials shall conform to IS: 73, IS: 215, IS: 217 or IS: 454 as applicable and be of the grade specified.

Table 5.6: Physical requirements of coarse aggregates for Bituminous concrete (BC).

(As per TABLE 500-17: MOSRTH specifications)

PROPERTY	TEST	SPECIFICATION
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve.
Particle shape	Flakiness and Elongation Index	Max 30% (Combined)2
Strength*	Los Angles Abrasion Value 3 Aggregate Impact Value4	Max 30% Max 24%
Polishing	Polished Stone Value5	Min 55
Durability	Soundness:6 Sodium Sulphate Magnesium Sulphate	 Max 12% Max 18%
Water Absorption	Water absorption7	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures9	Minimum retained coating 95%.
Water Sensitivity**	Retained Tensile Strength8	Min 80%

5.5 Earth work

5.5.1 Earthwork in Excavation

In general the excavation shall be in accordance to Specifications specified elsewhere.

Profiles of road excavation shall be laid at 50 m intervals or as specified in Drawings to conform to the required alignment, sections, grades and side slopes and the lines of cuts shall be clearly marked. Contractor shall on no account excavate beyond the slopes or below the specified grade unless so approved by the Engineer in writing. If excavation is done below the specified level or outside the section the Contractor shall be required to fill up with approved materials, in layers of 150 to 200 mm, watered and compacted as specified for the subgrade.

The excavation shall be finished neatly, smoothly and evenly to the correct lines, grades, sections as shown in the drawings or approved by Engineer.

5.5.2 Earthwork in Subgrade

The Subgrade shall be formed of approved soil excavated from road trenches and stacked separately.

Profiles of subgrade shall be set up with stout poles to mark the centre and edges of the formation with the top levels of formation clearly marked by paint or cut and the slopes with strings and pegs at every 10 metres on straight portions.

Subgrade material shall be placed in successive horizontal layers of 200 mm depth extending to the full width of the Subgrade / trench to allow compaction of the full specified section to 150 mm using mini rollers / tampers / plate vibrators till the soil is evenly compacted to 95% of Proctor density with

2% variation in optimum moisture content. Before placing the next layer of 200 mm the surface of the underlayer shall be moistured and scarified with pick axes or spades to provide a satisfactory bond with the next layer. The next layer shall also be compacted to 150 mm to the full width of the trench section till the soil is evenly compacted to 95% of Proctor density with 2% variation in optimum moisture content.

When boulders, broken stones and similar hard materials are mixed up with the embankment materials care shall be taken to see that they are distributed uniformly into the bank and that no hollows are left near them. No stone or hard material shall project above the top of any layer. Each layer of embankment shall be watered, levelled, and compacted as specified before the succeeding layer is placed. The surface of the embankment shall at all times during construction be maintained at such a cross fall as will shed water and prevent ponding.

If the soil contains less than the optimum moisture, water shall be added to the loose layers of the subgrade to bring the moisture uniformly upto requirement. If the material contains more than the required moisture it shall be allowed to dry until the moisture is reduced to the required extent. The moistured/dried loose layers shall be compacted with a vibratory roller / mini roller / plate vibrator/ tampers to achieve the desired compaction level of 95% of Proctor density.

5.6 Compaction with Sand / stone dust

In order to achieve better compaction and a compacted surface before laying the GSB layer, two layers of sand / stone dust shall be laid and compacted to 150 mm each.

5.7 Preparation of Granular Sub-base (GSB)

Spreading and Compacting: The granular sub base material of **grade-iii** as specified in **Table 5.2: Gradation for coarse graded granular Sub base** (As per Table-2 of Section 401 – MOSRTH Specifications) shall be spread on the prepared sub grade maintaining the required slope and grade during the operation or other means as approved by the Engineer.

When the sub base material consists of combination of materials mentioned in clause 401.21, mixing shall be done mechanically by the mix in- place method.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small – sized jobs. The equipment used for mix-in-place construction shall be rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS: 2720 (part 2) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 percent above to 2 percent below the optimum moisture content corresponding to IS: 2720 (part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavators until the layer is uniformly wet.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material determined as per IS: 2720 (part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material.

All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re – compacted.

5.8 Wet mix Macadam Course (WMM)

The GSB layer surface over which Wet mix Macadam (WMM) is to be laid shall be prepared to the specified grade and camber and made free of dust and other extraneous material.

Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm. WMM. sub-base course of specified thickness shall be provided. The course aggregate for this shall conform to requirements in **Table-5.7: Grading Requirements of Coarse Aggregates for Wet Mix Macadam (WMM)** (As per Table 400-11 of MOSRTH Specifications).

Table – 5.7: Grading Requirements of Coarse Aggregates for Wet Mix Macadam (WMM)
(As per Table 400-11 of MOSRTH Specifications)

IS Sieve Designation	Percent by weight passing the IS sieve
53.00 mm	100
45.00 mm	95 – 100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25-40
2.36 mm	15-30
600.00 micron	8-22
75.00 micron	0-8

5.8.1 Preparation of WMM layer

Preparation of mix: Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/positive mixing arrangement like pugmill or pan type mixer of concrete batching plant. For small quantity of wet mix work, the Engineer may permit the mixing to be done in concrete mixers.

Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

Spreading of mix: Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared subgrade /sub- base/base in required quantities. In no case should these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix may be spread either by a paver finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used so as to achieve the specified slope and grade. The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

Compaction: After the mix has been laid to the required thickness, grade and crossfall/camber the same shall be uniformly compacted, to the full depth with suitable vibratory roller. The speed of the roller shall not exceed 5 km/h.

5.9 Primer coat

Primer: The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC: 16. Surface of low porosity; such as wet mix macadam. The primer shall be bitumen emulsion.

Primer viscosity: The type and viscosity of the primer shall comply with the requirements of IS 8887, as sampled and tested for bituminous primer in accordance with these standards. Guidance on viscosity and rate of spray is given in **Table-5.8: Requirement of Viscosity and quantity of Liquid bituminous Primer** (As per Table 500-1 of MOSRTH Specifications).

Table-5.8: Requirement of Viscosity and quantity of Liquid bituminous Primer
(As per Table 500-1 of MOSRTH Specifications).

Type of surface	Kinematic Viscosity of Primer at 60°C (Centistokes)	Quantity of Liquid Bituminous Material per 10 Sq.m. (kg)
Low porosity	30-60	6 to 9
Medium porosity	70-140	9 to 12
High porosity	250-500	12 to 15

Preparation of road surface: The surface to be primed shall be prepared in accordance with Clauses 501.8. and 902 as appropriate. Immediately prior to applying the primer the surface shall be carefully swept clean of dust and loose particles, care being taken not to disturb the interlocked aggregate. This is best achieved when the surface layer is slightly moist (lightly sprayed with water and the surface allowed to dry) and the surface should be kept moist until the primer is applied.

Application of bituminous primer: The viscosity and rate of application of the primer shall be as specified in the Contract, or as determined by site trials carried out as directed by the Engineer. The bituminous primer shall be sprayed uniformly in accordance with Clause 501 of MOSRTH specifications. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed of forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

Curing of primer and opening to traffic: A primed surface shall be allowed to cure for at least 24 hours or such other period as is found to be necessary to allow all the volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with an application of sand, using the minimum quantity possible.

5.10 Tack coat

Over the primed surface, a tack coat should be applied in accordance with Clause 503 of MOSRTH Specifications.

The binder used for tack coat shall be bitumen emulsion complying with IS 8887 of a type and grade as specified in the Contract or as directed by the Engineer.

The tack coat distributor shall be a self-propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying of small areas, inaccessible to the distributor, or in narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and any extraneous material, and be otherwise prepared in accordance with the requirements of Clauses 501.8 and 902 as appropriate. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high pressure air jet, or by other means as directed by the Engineer.

The application of tack coat shall be at the rate specified in the Contract, and shall be applied uniformly. If rate of application of Tack Coat is not specified in the contract then it shall be at the rate specified in **Table-5.9: Requirement of Viscosity and quantity of Liquid bituminous Tack Coat** (As per Table 500-2 of MOSRTH Specifications).

Table-5.9: Requirement of Viscosity and quantity of Liquid bituminous Tack Coat
(As per Table 500-2 of MOSRTH Specifications).

	Type of Surface	Quantity of Liquid bituminous material in Kg per sq.m.area
i)	Normal bituminous surfaces	0.20 to 0.25
ii)	Dry and hungry bituminous surfaces	0.25 to 0.30
iii)	Granular surfaces treated with primer	0.25 to 0.30
iv)	Non bituminous surfaces	
	Granular base (not primed)	0.35 to 0.40
	Cement concrete pavement	0.30 to 0.35

The normal range of spraying temperature for a bituminous emulsion shall be 20°C to 70°C and for a cutback, 50°C to 80°C.

5.11 Bituminous Macadam

The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for "Paving Bitumen" IS:73.

Aggregate grading and binder content: When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined aggregate grading for the particular mixture shall fall within the limits shown in **Table-5.10: Composition of Bituminous macadam (BM)** (As per Table

500-4 of MOSRTH Specification) for the grading specified in the Contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type. The aggregates shall be proportioned and blended to produce a uniform mixture complying with the requirements of Table 500-4.

Table-5.10: Composition of Bituminous macadam (BM)
(As per Table 500-4 of MOSRTH Specification)

Mix designation	Grading 1	Grading 2
Nominal aggregate size	40mm	19 mm
Layer thickness	80 -100mm	50 - 75 mm
IS Sieve (mm)	Cumulative % by weight of total aggregate	
45	100	
37.5	90-100	
26.5	75-100	100
19	-	90-100
13.2	35-61	56-88
4.75	13-22	16-36
2.36	4-19	4-19
0.3	2-10	2-10
0.075	0-8	0-8
Bitumen content, % by weight of total mixture[1]	3.1 - 3.4	3.3 - 3.5
Bitumen grade	35 to 90	35 to 90

5.11.1 Preparation of the Base: The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with Clause 501.8 and 902.3 as appropriate, or as directed by the Engineer.

5.11.2 Preparation and transportation of the Mixture: The provisions of Clauses 501.3 and 501.4 shall apply.

5.11.3 Spreading: The provisions of Clauses 501.5.3 shall apply.

5.11.4 Compaction: Compaction shall be carried out in accordance with the provisions of Clause 501.6 and 501.7. The details of mixing, laying and rolling temperature of BM mix is as indicated in **Table-5.11: Manufacturing & rolling Temperature of BM mix** (As per Table 500-5 of MOSRTH Specifications)

Rolling shall be continued until the specified density is achieved, or where no density is specified, until there is no further movement under the roller. The required frequency of testing is defined in Clause 903.

Table-5.11: Manufacturing & Rolling Temperature of BM mix

(As per Table 500-5 of MOSRTH Specifications)

Bitumen Penetration	Bitumen Mixing (°C)	Aggregate Mixing (^{o} C)	Mixed Material (°C)	Rolling ($_{o}$ C)	Laying ($_{o}$ C)
35	160 - 170	160-175	170 Maximum	100 Minimum	130 Minimum
65	150 - 165	150-170	165 Maximum	90 Minimum	125 Minimum
90	140 - 160	140- 165	155 Maximum	80 Minimum	115 Minimum

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, within a maximum of forty-eight hours. If there is to be any delay, the course shall be covered by a seal coat to the requirement of Clause 513 before opening to any traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

5.12 Bituminous Concrete

This work shall consist of construction in a single layer of bituminous concrete on a previously prepared Bituminous Macadam (BM) surface.

Bitumen: The bitumen shall be paving bitumen of Penetration grade complying with Indian Standard Specification for Paving Bitumen, IS: 73 and of the penetration indicated in Table 500-18, for bituminous concrete.

The coarse aggregates shall be generally as specified in Clause 507.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-17.

Requirements for the mixture: Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in **Table-5.12: Composition of Bituminous Concrete** (As per Table 500-18 of MOSRTH Specifications) and **Table-5.13: Requirement of Bituminous Concrete** (As per Table 500-19: of MOSRTH Specifications).

Table-5.12: Composition of Bituminous Concrete (As per Table 500-18 of MOSRTH Specifications).

Grading	**1**	**2**
Nominal aggregate size	**13 mm**	10 mm
Layer Thickness	**35-40 mm**	25-30 mm
IS Sieve[1] (mm)	**Cumulative % by weight of total aggregate passing**	
45		
37.5		
26.5	**100**	
19	**79-100**	100
13.2	**59-79**	79-100
9.5	**52-72**	70-88
4.75	**35-55**	53-71
2.36	**28-44**	42-58
1.18	**20-34**	34-48
0.6	**15-37**	26-38
0.3	**10-20**	18-28
0.15	**5-13**	12-20
0.075	**2-8**	4-10
Bitumen content % by mass of total mix[2]	**5.0 - 6.0**	5.0 - 7.0
Bitumen grade (pen)	**65**	65

Notes: 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

2. Determined by the Marshall method.

3. Job mix formula shall be generally as specified in Clause 507.3.3 and the results of tests enumerated in Table 500-19.

Table-5.13: Requirement of Bituminous Concrete

(As per Table 500-19: of MOSRTH Specifications)

Minimum stability (kN at 60 ^{o}C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3-6
Per cent voids in mineral aggregate (VMA)	See Table 500-12 below
Per cent voids filled with bitumen (VFB)	65-75
Loss of stability on immersion in water at 60^{o}C (ASTM D 1075)	Min. 75 per cent retained strength

5.12.1 Rolling

Immediately after the spreading of mix it shall be thoroughly compacted by rolling with vibratory rollers moving at a speed not more than 5 km per hour. Rolling shall be continued till the mix is thoroughly compacted to meet the general provisions of clauses 501.6 and 501.7.

5.12.2 Opening to Traffic

Traffic shall be allowed on the road after a lapse of minimum 24 hours, preferably 48 hours after laying as approved by the Employer's Representative.

5.13 Quality Control of Road restoration works

5.13.1 General

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to increase the frequencies of tests as he may deem necessary to satisfy himself that the materials and works comply with the appropriate Specifications.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the approval of the Engineer.

5.13.2 Tests on Earthwork for Embankment and Subgrade Construction

(i) Sand content [IS:2720(Part IV)]
1-2 tests per 8000 cu. metres of soil

(ii) Plasticity Test [IS:2720(Part V)]
Each type to be tested , 1-2 tests per 8000 cu. metres of soil.

(iii) Density Test [[IS:2720(Part VII)].
Each soil type to be tested, 1-2 tests per 8000 cubic metres of soil.

(iv) Deleterious Content Test [IS:2720(PartXXVII)] As and when required by the Engineer.

(v) Moisture Content Test [IS:2720(Part II)]
One test for every 250 cubic metres of soil.

(vi) CBR Test on materials to be incorporated in the subgrade on soaked/unsoaked samples [[IS:2720(part XVI)]

One test for every 3000 m^3 at least or closer as and when required by the Engineer.

5.13.3 Compaction control:

Control shall be exercised by taking at least one measurement of density for each 500 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluation a days work on statistical basis. The determination of density shall be in accordance with IS:2720 (part XXVIII). Tests locations shall be chosen only through random sampling techniques. Control shall not be based on the result of any one test but on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 5 as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the

minimum number of tests in one set of measurement shall be increased to 10. The acceptance of work shall be subject to the condition that the mean dry density equals or exceeds the specified density and the standard deviation for any set of results is below 0.08 gm/cc.

However, for earthwork in subgrade and in top 500 mm portion of the embankment below the subgrade, at least one density measurement shall be taken for every 100 square metres of the compacted area provided further `that the number of tests in each set of measurements shall be at least 10. In other respects, the control shall be similar to that described earlier.

5.13.4 Tests on Granular Sub base (GSB) and Wet mix macadam (WMM) layers

The tests and their frequencies for the different types of bases and sub-base shall be as given in **Table 5.14**. The evaluation of density results for compaction control shall be on lines similar to those set out in clause 5.10.1.

Table –5.14: Control Tests and their frequencies for Granular Sub base (GSB) and Wet mix macadam (WMM) layers

Sl. No.	Types of Construction	Test	Frequency
1.	Granular sub-base	i) Gradation ii) Atterbergs limit iii) Moisture content prior to compaction iv) Density of compacted layer v) Deleterious constituents vi) C.B.R	One test per 200 m^3 One test per 200 m^3 One test per 250 m^2 One test per 500 m^2 As required As required
2.	Lime/Cement Stabilised	i) Purity of lime (for lime-soil stabilization ii) Lime/Cement content iii) Degree of pulverisation iv) CBR test on a set of 3 specimens v) Moisture content prior to compaction vi) Density of compacted layer vii) Deleterious constituents	One test for each consignment subject to a minimum of one test per 5 tonnes of lime. Regularly, through procedural checks. Periodically as considered necessary. As required One test per 250 m^3. One test per 500 m^2 As required
3	Wet mix Macadam	i) Aggregate Impact Value ii) Grading iii) Flakiness Index iv) Atterberg limits of portion of aggregate passing 425 micron sieve	One test per 200m^3 of aggregate One test per 100 m^3 of aggregate One test per 200 m^3 of aggregate One test per 100 m^3

5.13.5 Tests on Bituminous Constructions

The tests and their frequencies for the different types of bituminous works shall be as given in **Table- 5.15** hereunder.

Table – 5.15: Control Tests and their Frequency for Bituminous Works

Sl. No.	Types of Construction	Test	Frequency
1.	Prime Coat/Tack Coat	i) Quality of binder ii) Binder temperature for a application iii) Rate of spread of binder	As Required At regular close intervals Two tests per day
2	Bituminous macadam (BM) / Bituminous Concrete (BC)	i) Quality of binder ii) Aggregate impact value, flakiness index and stripping value of aggregates iii) Mix-grading iv) Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling v) Stability of mix (vide ASTM:D-1559) vi) Binder content and gradation in the mix (Binder content test vide ASTM:D-2172) vii) Rate of spread of mixed material viii) Density of compacted layer	As required One test per 50-100m^3 aggregate One set of test on individual constituents and mixed aggregates from the dryer for each 100 tonnes of mix subject to a maximum of two sets per plant per day. At regular close interval. For each 100 tonnes of mix produced, a set of three Marshall specimens to be prepared and tested for stability, flow value density, and void content, subject to a minimum of two sets being tested per plant per day. One test for each 100 tonnes of mix subject to a minimum of two tests per day per plant. Regular control thro checks on the weight of mixed material and layer thickness. One test per 250 m^2 area

5.14 Slab Culvert

Slab culverts shall be constructed at specified locations of the existing cross drainage works as per drawings, or as directed by the Engineer. The Concrete works specifications for construction of RC slab and the rubble masonry specifications for the supporting rubble walls are given in Section-4 and Section-8 respectively and they shall be followed.

5.14.1 Bitumen at Location of Contact

The Bitumen to be used on the top of the bed concrete at the location of contact of RCC slab above in two coats, shall be straight run bitumen of specified grade.

5.14.2 Graded Gravel Free Draining Backfill

On each side of the uncoursed rubble walls supporting the slab culvert a free draining backfill of thickness 200 mm shall be provided. The material for this backfill shall be granular consisting of sound, tough, durable particles of crushed or uncrushed gravel, crushed stone or brickbats which will not become powdery under loads and in contact with water. The material shall be free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall be graded and shall meet the grading requirements given in Table 5.16 hereunder.

Table 5.16

Sieve Designation	Percent Passing by Weight
10 mm	100
4.75 mm	30-65
425 microns	5-30
150 microns	0-10

5.14.3 Weep Holes

Weep holes as shown on the drawings or as directed by the Engineer shall be provided in the masonry to drain water from the backfilling. Weep holes shall be of asbestos cement pipes conforming to IS 6908 in rubble walls with necessary M10 concrete cushioning, 75 mm thick. They shall extend through the full width of the masonry at a spacing of 1.5 m c/c and with slope of about 1 vertical to 20 horizontal (or as shown on the drawings) towards the draining face.

5.15 Pipe Drains

Wherever required, pipe drains shall be provided for cross drainage purposes. The sequence of construction shall be as follows:

(a) laying of sand/shingle bedding on the original ground,
(b) laying of PCC of M10 grade,
(c) laying of concrete pipes of NP3 class as per IS 458,
(d) Constructing embankment above in compacted murum, laying of the sub-base and Waterbound Macadam as specified herein above.

The details of above works as directed by Engineer shall be followed.

5.15.1 Materials for Pipe Drains

All materials used in the construction of pipe drains shall conform to the requirements of the Specifications. RCC pipes of NP3 class shall conform to IS 458.

Each consignment of cement concrete pipes shall be inspected, tested if necessary, and approved by Engineer at the place of manufacture or at site before their incorporation in the Works.

5.15.2 Excavation for pipes

The foundation bed for pipe drain shall be executed true to the lines and grades shown on the drawings or as directed by the Engineer. The pipes shall be placed in shallow excavation of the natural ground in open trenches cut in the existing embankment, taken down to levels as shown in the drawings. Where trenching is involved, its width on either side of pipe shall not be less than 200 mm nor more than one third the diameter of pipe. The sides of the trench shall be as nearly vertical as possible.

When during excavation, the material encountered is soft, spongy or other unstable soil, unless other special construction methods are called for as indicated on drawings, such unsuitable material shall be removed upto a depth of 600 mm or as directed by the Engineer. Before placing any backfill material, exposed surface of the soft soil shall be lightly compacted with one pass of 0.5 T roller. On the lightly compacted surface, coarse sand and shingle shall be spread in two successive layers of 300 mm and each layer shall be compacted by rolling with a min.0.5 T roller and with a minimum of 10 passes each, both in longitudinal and transverse directions.

When bed rock or boulder strata are encountered, excavation shall be taken down at least 300 mm below bottom level of pipe as directed by Engineer and space filled with approved sand and shingle and thoroughly compacted to provide adequate support for the pipes.

Trenches shall be kept free from water until the pipes are installed and the joints have been hardened. For this purpose, Contractor shall suggest necessary method for diverting the water.

5.15.3 Bedding for pipe

The bedding surface shall provide a firm foundation of uniform density throughout the length of the pipe drain and shall conform to the specified level and grade.

The pipe shall be bedded in a cradle of concrete having a mix not leaner than M-10. The pipes shall be laid on the concrete bedding before the concrete has set.

5.15.4 Laying of pipes

No pipe shall be placed in position until the foundations have been approved by Engineer. When pipes are to be laid adjacent to each other, they shall be separated by a distance atleast equal to or greater than half the diameter of pipe subject to a minimum of 450 mm.

The laying of pipes on the prepared concrete foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades. The pipes shall be fitted and matched so that when laid they form a drain with a smooth uniform invert.

Any pipe found defective or damaged during laying shall be removed at the cost of the Contractor.

5.15.5 Jointing

All the joints shall be made with care so that their interior face is smooth and consistent with the interior surface of the pipes. The ends of the pipes should be so shaped as to form a self-centering joint with jointing space 13 mm wide. The jointing space shall be filled with cement mortar (1 cement to 2 sand) mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed. After finishing, the joints shall be kept covered and damp for at least four days.

5.15.6 Back filling

Trenches shall be backfilled with selected murum as per specifications given in this part. Backfilling upto 0.3 metre above the top of pipe shall be carefully done and murum shall be thoroughly consolidated under the haunches of the pipe.

5.16 Measurement

5.16.1 Slab Culvert

(a) Measurement of in-situ concrete work shall be as specified in Section 4 of this specification.

(b) Measurement of masonry shall be as specified in Section 8 of this specification.

(c) Bitumen at locations of contact with concrete surface shall be measured in square metres over area covered in plan and the rates shall include cleaning the surfaces, applying in two coats, etc., as specified.

(d) Graded gravel free draining backfill shall be measured in cubic metres and the rate shall include supplying, backfilling, etc., as specified.

(e) Measurement for weep holes shall be running metres and the rates shall include providing and fixing in rubble masonry walls with necessary concrete cushioning to lines and levels as specified.

5.16.2 Pipe Drains

Ancillary works such as excavation, backfilling, laying P.C.C below pipe, etc., shall be paid for separately, as provided under respective clauses.

End of Section 5

SECTION 6

STRUCTURAL STEEL WORK

SECTION 6
STRUCTURAL STEEL WORK

6 Applicable Codes and Specifications

The supply, fabrication, erection and painting of structural steel works shall comply with the following specifications, standards and codes unless otherwise specified herein. All standards, specifications and codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions.

1.	IS : 808	Dimensions for Hot Rolled Steel Beam, Column, Channel & Angle sections
2.	IS : 814	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Maganese Steel - Specifications
3.	IS : 800	Code of Practice for General Construction in Steel
4.	IS : 801	Code of Practice for Use of Cold Formed Light Gauge Steel Structural Members in General Building Construction
5.	IS : 806	Code of Practice for Use of Steel Tubes in General Building Construction
6.	IS : 7205	Safety Code for Erection of Structural Steel Work
7.	IS : 7215	Tolerances for Fabrication of Steel Structures
8.	IS : 4000	High Strength Bolts in Steel Structure – Code of Practice
9.	AISC	Specifications for Design, Fabrication and Erection of Buildings
10.	IS : 1161	Steel Tubes for structural purposes - Specifications
11.	IS:102	Ready Mixed paint, Brushing, Red Lead, Non-setting, Priming.
12.	IS:110	Ready Mixed paint, brushing, grey filler for enamels for use over primers.
13.	IS:117	Ready Mixed paint, Brushing, Finishing, Exterior Semigloss for general purposes, to Indian Standard colours.
14.	IS:158	Ready Mixed paint, Brushing, Bituminous, Black, Lead free, Acid, Alkali and heat resisting.
15.	IS:159	Ready Mixed paint, Brushing, Acid resisting for protection against acid fumes, colour as required.
16.	IS:341	Black Japan, Types A, B and C
17.	IS:2339	Aluminium paint for general purposes, in Dual container
18.	IS:2932	Specification for enamel, synthetic, exterior, type 1, (a) undercoating, (b) finishing
19.	IS:2933	Specification for enamel, exterior, type 2, (a) undercoating, (b) finishing
20.	IS:5905	Sprayed aluminium and zinc coatings on Iron and Steel.
21.	IS:6005	Code of practice for phosphating of Iron and Steel.
22.	IS:9862	Specification for ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water & chlorine resisting.

23.	IS:13183	Aluminium paint, Heat resistant - Specifications
24.	SIS-05-5900	(Swedish Standard)
25.	IS : 1239	Mild steel tubes, tubulars and other Wrought steel fittings Part 1 – Mild steel tubes Part 2 – Mild steel tubulars and other wrought steel pipe fittings
26.	IS : 1363 (Parts 1 to 3)	Hexagon Head Bolts, Screws and Nuts of product Grade C (Size range M5 to M64)
27.	IS : 1367	Technical Supply Conditions for Threaded Steel Fasteners (All parts)
28.	IS : 1852	Rolling and Cutting Tolerances for Hot Rolled Steel Products
29.	IS : 1977	Structural Steel (Ordinary Quality) Low Tensile Structural Steel - Specifications
30.	IS : 2062	Steel for General Structural Purposes - Specifications
31.	IS : 2074	Ready Mixed Paint, Air drying, Red Oxide Zinc Chrome and Priming - Specifications
32.	IS : 3502	Steel Chequered Plate - Specifications
33.	IS : 3757	Specifications for High Strength Structural Bolts
34.	IS : 5369	General Requirements for Plain Washers and Lock Washers
35.	IS : 5372	Taper Washers for Channels (ISMC)
36.	IS : 5374	Taper Washer for 1 Beams (ISMB)
37.	IS : 6610	Specifications for Heavy Washers for Steel Structures
38.	IS : 8500	Structural Steel-microalloyed (medium and high strength qualities) - Specifications
39.	IS : 803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded storage tanks
40.	IS : 816	Code of Practice for use of Metal Arc Welding for General construction in Mild Steel
41.	IS : 822	Code of Procedure for Inspection of Welds
42.	IS : 1182	Recommended Practice for Radiographic examination of Fusion – Welded Butt Joints in Steel Plates
43.	IS : 1200	Method of Measurement in Building and Civil Engineering Works
44.	IS : 1477	Code of Practice for Painting of (Parts 1&2) Ferrous Metals in Buildings
45.	IS : 2595	Code of Practice for Radiographic Testing
46.	IS : 3658	Code of Practice for Liquid Penetrant Flaw Detection
47.	IS : 5334	Code of Practice for Magnetic Particle Flaw Detection of Welds
48.	IS : 9595	Recommendations for Metal Arc Welding of Carbon and Carbon Manganese Steel
49.	IS : 1367	Technical, Supply, Conditions for steel (Part 13) threaded steel fasteners
50.	IS : 1573	Specifications for Electroplated Coating of Zinc on Iron and Steel
51.	IS : 2629	Recommended Practice for Hot Dip Galvanising of Iron and Steel
52.	IS : 2633	Method of Testing Uniformity of Coating on Zinc Coated Articles
53.	IS : 4736	Specifications for Hot Dip Zinc coating on Mild steel tubes

54.	IS : 4759	Hot Dip Zinc coating on Structural Steel and other Allied products
55.	IS : 5905	Sprayed Aluminium and Zinc Coatings on Iron and Steel
56.	IS : 6158	Recommended Practice for Safeguarding against Embrittlement of Hot Dip Galvanised Iron and Steel Products
57.	IS : 6159	Recommended Practice for Design and fabrication of Iron & Steel Products Prior to Galvanising & Metal Spraying
58.	IS : 6745	Methods for Determination of Mass of Zinc Coating on Zinc coated Iron and Steel Articles
59.	SP: 38-1997	Handbook of Typified Design of Structures with Steel Roof Trusses

6.1 Steel Materials

Steel materials shall comply with the codes referred to in Sub-Clause 6.1.

All materials used shall be new, unused and free from defects.

Steel conforming to IS:1977 shall be used only for the following :

Fe310-0(St 32-0)	For general purposes such as door/window frames, grills, steel gates, fence posts, tee bars and other non-structural use.
Fe410-0(St 42-0)	For structures not subjected to dynamic loading other than wind loads such as : Platform roofs, foot over bridges, building, factory sheds etc.
Fe10-0(St 42-0)	Grade steel shall not be used a) If welding is to be employed for fabrication b) If site is in severe earthquake zone c) If plastic theory of design is used

6.2 Drawings prepared by the Employer

Design drawings will be furnished to the Contractor and all drawings so furnished shall form a part of this specification in case of Item Rate Contracts. These design drawings prepared by the Engineer will show all the levels, forces on members where shall necessary, size and orientation of each member, location/size of openings to enable the Contractor to prepare drawings for fabrication and erection. It shall be clearly understood that these drawings are not intended to show connection details, thickness of members, cuts, notches, bends and such other details.

The Engineer reserves the right to make changes. Revisions to drawings, even after release for preparation of shop drawings, are very likely to be made to reflect additional data/details received and updated requirements. Revisions to drawings and any new drawings made to include additional work

by the Contractor shall be considered a part of this specification and contract. The Employer shall not entertain any extra claims on this account.

Where the fabrication drawings are to be furnished by the Engineer, he will issue to the Contractor the required copies of such drawings in the sequence required for the fabrication of the components

in the order they will be required to be erected at site. Such drawings will be issued in such numbers as required for the Contractor to adhere to the project schedule.

Should the Contractor during the execution of his work, find discrepancies in the information furnished by the Engineer, he shall refer such discrepancies to the Engineer before proceeding with the work.

6.3 Drawings prepared by the Contractor

The Contractor shall prepare all fabrication and erection drawings for the entire work. All the drawings for the entire work shall be prepared in metric units. The drawings shall preferably be of one standard size and the details shown there in shall be clear and legible.

The Contractor shall not commence detailing unless Engineer's design drawings are officially released for preparation of shop drawings. The Contractor shall be responsible for the correctness of all fabrication drawings. Fabrication drawings shall be revised by the Contractor to reflect all revisions in design drawings as and when such revisions are made by the Engineer.

All fabrication drawings shall be submitted to the Engineer for approval.

No fabrication drawings will be accepted for Engineer's approval unless checked and approved by the Contractor's qualified structural engineer and accompanied by an erection plan showing the location of all pieces detailed. The Contractor shall ensure that connections are detailed to obtain ease in erection of structures and in making field connections.

Fabrication shall be started by the Contractor only after Engineer's approval of fabrication drawings. Approval by the Engineer of any of the drawings shall not relieve the Contractor from the responsibility for correctness of engineering and design of connections, workmanship, fit of parts, details, material, errors or omissions of any and all work shown thereon. The Engineer's approval shall constitute approval of the size of members, dimensions and general arrangement but shall not constitute approval of the connections between members and other details.

The drawings prepared by the Contractor and all subsequent revisions etc. shall be at the cost of the Contractor for which no separate payment will be made.

6.4 Fabrication

6.4.1 General

All workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined/ground smooth true and square where so specified. All holes and edges shall be free of burrs. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Unless otherwise approved by the Employer's Representative, reference may be made to relevant BIS codes for providing standard fabrication tolerance. Material at the shops shall be kept clean and protected from weather.

6.4.2 Connections

Shop/field connections shall be as per approved fabrication drawings.

In case of bolted connections, taper washers or flat washers or spring washers shall be used with bolts as necessary. In case of high strength friction grip bolts, hardened washers be used under the nuts or the bolt heads whichever are turned to tighten the bolts. The length of the bolt shall be such that atleast one thread of the bolt projects beyond the nut, except in case of high strength friction grip bolts where this projection shall be at least three times the pitch of the thread.

In all cases where bearing is critical, the unthreaded portion of bolt shall bear on the members assembled. A washer of adequate thickness may be provided to exclude the threads from the bearing thickness, if a longer grip bolt has to be used for this purpose.

All connections and splices shall be designed for full strength of members or loads. Column splices shall be designed for the full tensile strength of the minimum cross section at the splice.

All bolts, nuts, washers, electrodes, screws etc., shall be supplied/brought to site 10% in excess of the requirement in each category and size. Rates shall cover the cost of this extra quantity.

All members likely to collect rain water shall have drain holes provided.

6.4.3 Straightening

All materials, shall be straight and, if necessary, before being worked shall be straightened and/or flattened by pressure and shall be free from twists. Heating or forging shall not be resorted to without the prior approval of the Employer's Representative in writing.

6.4.4 Rolling and Forming

Plates, channels, R.S.J. etc., for circular bins, bunkers, hoppers, gantry girders, etc., shall be accurately laid off and rolled or formed to required profile/shape as called for on the drawings. Adjacent sections shall be match-marked to facilitate accurate assembly, welding and erection in the field.

6.4.5 High Strength Friction Grip Bolting

Inspection after tightening of bolts shall be carried out as stipulated in the appropriate standards depending upon the method of tightening and the type of bolt used.

6.4.6 Welding

Welding procedure shall be submitted to the Employer's Representative for approval. Welding shall be entrusted to qualified and experienced welders who shall be tested periodically and graded as per IS 817, IS : 7310 (Part 1) and IS : 7318 (Part 1).

While fabricating plated beams and built up members, all shop splices in each component part shall be made before such component part is welded to other parts of the members. Wherever weld reinforcement interferes with proper fit-up between components to be assembled off welding, these welds shall be ground flush prior to assembly.

Approval of the welding procedure by the Employer's Representative shall not relieve the Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.

No welding shall be done when the surface of the members is wet nor during periods of high wind.

Each layer of a multiple layer weld except root and surfaces runs may be moderately peened with light blows from a blunt tool. Care shall be exercised to prevent scaling or flaking of weld and base metal from overpeening.

No welding shall be done on base metal at a temperature below –5 Deg.C. Base metal shall be preheated to the temperature as per relevant BIS codes.
Electrodes other than low-hydrogen electrodes shall not be permitted for thicknesses of 32 mm and above.

All welds shall be inspected for flaws by any of the methods described under Sub-clause 6.8.3. The choice of the method adopted shall be agreed with the Employer's Representative.

The correction of defective welds shall be carried out in a manner approved by the Employer's Representative without damaging the parent metal. When a crack in the weld is removed, magnetic particle inspection or any other equally positive means approved by the Employer's Representative shall be used to ensure that the whole of the crack and material upto 25 mm beyond each end of the crack has been removed. The cost of all such tests and operations incidental to correction shall be borne by the Contractor.

6.5 Tolerances

The dimensional and weight tolerances for rolled shapes shall be in accordance with IS : 1852 for indigenous steel and equivalent applicable codes for imported steel. The tolerances for fabrication of structural steel shall be as per IS : 7215.

Cutting, punching, drilling, welding and fabrication tolerances shall be generally as per relevant BIS codes.

6.6 End Milling

Where compression joints are specified to be designed for bearing, the bearing surfaces shall be milled true and square to ensure proper bearing and alignment.

6.7 Inspection

6.7.1 General

The Contractor shall give due notice to the Employer's Representative in advance of the works being made ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for the Employer's Representative's inspection. The fact that certain material has been accepted at the Contractor's shop shall not invalidate final rejection at site by the Employer's Representative if it fails to conform to the requirements of these specifications, to be in proper condition or has fabrication inaccuracies which prevent proper assembly nor shall it invalidate any claim which the Employer may make because of defective or unsatisfactory materials and/or workmanship.

No materials shall be painted or despatched to site without inspection and approval by the Employer's Representative unless such inspection is waived in writing by the Employer's Representative.

The Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified.

For fabrication work carried out in the field the same standard of supervision and quality control shall be maintained as in shop fabricated work. Inspection and testing shall be conducted in a manner satisfactory to the Employer's Representative.

Inspection and tests on structural steel members shall be as set forth below.

6.7.2 Material Testing

If mill test reports are not available for any steel materials the same shall be tested by the Contractor to the Employer's Representative's satisfaction to demonstrate conformity with the relevant specification.

6.7.3 Tests on Welds

6.7.3.1 Magnetic Particle Test

Where welds are examined by magnetic particle testing, such testing shall be carried out in accordance with relevant BIS codes. If heat treatment is performed, the completed weld shall be examined after the heat treatment. All defects shall be repaired and retested. Magnetic particle tests shall be carried out using alternating current. Direct current may be used with the permission of the Employer's Representative.

6.7.3.2 Liquid Penetrant Inspection

In the case of welds examined by Liquid Penetrant Inspection, such tests shall be carried out in accordance with relevant BIS Code. All defects shown shall be repaired and rechecked.

6.7.3.3 Radiographic Inspection

All full strength butt welds shall be radiographed in accordance with the recommended practice for radiographic testing as per relevant BIS code.

6.7.4 Dimensions, Workmanship & Cleanliness

Members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment, surface finish and painting are in accordance with the requirements shown in the Contractor's approved fabrication drawings.

6.7.5 Test Failure

In the event of failure of any member to satisfy inspection or test requirement, the Contractor shall notify the Employer's Representative. The Contractor must obtain permission from the Employer's Representative before any repair `is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by the Employer's Representative.

The Employer's Representative has the right to specify additional testing as he deems necessary, and the additional cost of such testing shall be borne by the Employer, only in case of successful testing.

The Contractor shall maintain records of all inspection and testing which shall be made available to the Employer's Representative.

6.8 Shop Matching

For structures like bunkers, tanks, etc. shop assembly is essential. For other steel work, such as columns along with the tie beams/bracings may have to be shop assembled to ensure satisfactory fabrication, obtaining of adequate bearing areas etc., if so desired by the Employer's Representative. All these shop assemblies shall be carriedout by the Contractor.

6.9 Marking of Members

After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it. The erection mark shall be stamped with a metal dye with figures at least 20 mm high and to such optimum depth as to be clearly visible.

All erection marks shall be on the outer surface of all sections and near one end, but clear of bolt holes. The marking shall be so stamped that they are easily discernible when sorting out members. The stamped marking shall be encircled boldly by a distinguishable paint to facilitate easy location.

Erection marks on like pieces shall be in identical locations. Members having lengths of 7.0 m or more shall have the erection mark at both ends.

6.10 Errors

Any error in shop fabrication which prevents proper assembling and fitting up of parts in the field by moderate use of drift pins or moderate amount of reaming will be classified by the Employer's Representative as defective workmanship. Where the Employer's Representative rejects such material or defective workmanship, the same shall be replaced by materials and workmanship conforming to these Employer's Requirements by the Contractor, at no cost to the Employer.

6.11 Site Operations

The Contractor shall complete all preliminary works at site well before the arrival of structural steel, such as establishment of a well equipped and adequately staffed site office, stores, unloading gantry, unloading pre-assembly yard, labour quarters if any, electrical and water connections, electrical winches, derricks, cranes, compressors, all tools and tackles, rivet guns, welding sets, torque wrenches, spud wrenches, staging, etc., as well as experienced erection and supervisory personnel as part of this contract and any other work that may be necessary so as to start erection immediately after the arrival of the first batch of steel on site.

The Contractor shall furnish at his own expense, the necessary non-inflammable staging and hoisting materials or equipment required for the erection work and shall remove and take them away after completion of the job. The Contractor shall also provide necessary passageways, fences, safety belts,

helmets, lights and other fittings to the satisfaction of the Employer's Representative and to meet the rules of local authorities and for protection to his men and materials. A licensed electrician shall be kept on the job for the entire duration of the work to maintain the Contractor's electrical equipment and connections.

The Contractor shall protect all existing plant, structures, piping, conduits, equipment and facilities against damage during erection. Any damage caused by contractor shall be rectified entirely at his cost, to the satisfaction of the Employer's Representative. If work has to be carried out adjacent to existing switch yards or electrical installations which are live, the Contractor must ensure suitable safety precautions in consultation with Employer's Representative.

If a portion of the work of the project area cannot be made available to the Contractor for his activities due to operations being carried out by other agencies, he shall suitably modify his sequence of operations so as to continue work without interruption. The Contractor shall work in co-ordination with other agencies working on the project site and plan his work suitably so as not to hinder the progress of construction at site.

6.12 Acceptance of Steel, its Handling & Storage

The Contractor shall carefully check the steel to be erected at the time of acceptance. Any fabrication defects observed should be brought to the notice of the Employer's Representative.

No dragging of steel shall be permitted. All steel shall be stored 300mm above ground on suitable packing to avoid damage. It shall be stored in the order required for erection, with erection marks visible. All storage areas shall be prepared and maintained by the Contractor. Steel shall not be stored in the vicinity of areas where excavation or grading will be done and, if so stored temporarily, this shall be removed by the Contractor well before such excavation and/or grading commences to a safe distance to avoid burial under debris.

Scratched or abraded steel shall be given a coat of primer in accordance with these Employer's Requirements for protection after unloading and handling prior to erection. All milled and machined surfaces shall be properly protected from rust/corrosion by suitable coating and also from damage.

6.13 Anchor Bolts & Foundations

The Contractor shall carefully check the location and layout of anchor bolts embedded in foundations constructed, to ensure that the structures can be properly erected as shown on the drawings. Any discrepancy in the anchor bolts/foundation shall be reported to the Employer's Representative.

Leveling of column bases to the required elevation may be done either by providing shims or three nuts on the upper threaded portion of the anchor bolt. All shim stock required for keeping the specified thickness of grout and in connection with erection of structures on foundations, crane brackets or at any other locations shall be of good M.S. plates and shall be supplied by the Contractor at his cost.

A certain amount of cleaning of foundations and preparing the area is considered normal and shall be carried out by the Contractor at no extra cost.

Where beams bear in pockets or on walls, bearing plates shall be set and levelled as part of the work. All grouting under column base plates or beam bearing plates will be carried out by the Contractor.

6.14 Assembly & connections

Field connections may be effected either by riveting, bolting, welding or by use of high strength friction grip bolts as shown on the design and erection drawings.

All field connection work shall be carried as per the drawings prepared by the Contractor. All bolts, nuts, washers, rivets, electrodes required for field connections shall be supplied by the Contractor.

All assembling shall be carried on a level platform.

Drifts shall be used only for drawing the work to proper position and must not be used to such an extent as to damage the holes. Size of drifts larger than the normal diameter of hole shall not be used. Any damaged holes or burrs must be rectified to the satisfaction of the Employer's Representative.

Corrections of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets shall be considered as a part of erection. Any error in the shop, which prevents proper fit on a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the Employer's Representative.

6.15 Erection

All structural steel shall be erected as shown on the drawings prepared by the Contractor. Proper size steel cable slings, etc., shall be used for hoisting. Guys shall not be anchored to existing structures, foundations, etc., unless so permitted by the Employer's Representative in writing. Care shall be taken to see that ropes in use are always in good condition.

Steel columns in the basement, if any, are to be lowered and erected carefully with the help of a crane and/or derrick without damaging the basement walls or floor.

Structural steel frames shall be erected plumb and true. Frames shall be lifted at points such that they are not liable to buckle and deform. Trusses shall be lifted only at node points. In the case of trusses, roof girders, all of the purlins and wind bracing shall be placed simultaneously and the columns shall be erected truly plumb on screed bars over the pedestals. All steel columns and beams shall be checked for

plumb and level individually before and after connections are made. Temporary bracings shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including erection equipment and the operation thereof. Such bracings shall be left in place as long as may be required for safety and stability.

Chequered plates shall be fixed to supporting members by tack welding or by countersunk bolts as shown/specified in relevant drawings and/or as approved by the Employer's Representative. The edges shall be made smooth and no burrs or jagged ends shall be left. While splicing, care should be taken so that there is continuity in pattern between the two portions. Care should also be taken to avoid distortion of the plate while welding. The erection of chequered plates shall include:

(a) Welding of stiffening angles/vertical stiffening ribs
(b) Cutting to size and making holes to required shape wherever necessary to allow service piping and/or cables to pass through
(c) Splicing as shown in relevant drawings
(d) Smoothening of edges
(e) Fixing of chequered plates by tack welding or by countersunk bolts
(f) Providing lifting hooks for ease of lifting.

As erection progresses, the work shall be securely bolted to take care of all dead load, wind, seismic and erection stresses.

No riveting or welding or final bolting shall be done until the structure has been properly aligned and approved by the Employer's Representative. No cutting, heating or enlarging of the holes shall be carried out without the prior written approval of the Employer's Representative.

Test certificates shall be furnished by the Contractor.

6.16 Inspection

The Employer's Representative shall have free access to all parts of the job during erection and all erection shall be subjected to his approval. In case of faulty erection, all dismantling and re-erection required will be at the Contractor's cost. No paint shall be applied to rivet heads or field welds or bolts until these have been approved by the Employer's Representative.

6.17 Tolerances

6.17.1 General

Tolerances mentioned below shall be achieved after the entire structure or part thereof is in line, level and plumb.

6.17.2 Columns

Deviation of column axes at foundation top level with respect to true axes:

(a)	In longitudinal direction	±5 mm
(b)	In lateral direction	±5 mm

Deviation in the level of bearing surface of columns at foundation top with respect to true level	±5mm

Out of plumbness (verticality) of column axis from true vertical axis, as measured at column top :

(a)	For columns upto and including 15 metres in height	±1/1000 of column height in mm or ±15 mm whichever is less
(b)	For columns exceeding 15 metres in height	±1/1000 of column height in mm or ±20 mm whichever is less

Deviation in straightness in longitudinal and transverse planes of column at any along the height	±1/1000 of column height in mm or ±10 mm whichever is less point

Difference in erected position of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance	±10mm

Deviation in any bearing or seating level with respect to true level	±5 mm
Deviation in differences in bearing level of a member on adjacent pair of columns both across and along the building	±10 mm

6.17.3 Trusses And Beams

Shift at the centre of span of top chord member with respect to the vertical plane passing through the centre of bottom chord	±1/250 of height of truss in mm or ±15 mm whichever is less
Lateral shift of top chord of truss at the centre of span from the vertical plane passing through the centre of supports of the truss	±1/1500 of span of truss in mm or ±15 mm whichever is less
Lateral shift in location of truss from its true vertical position	±10 mm
Lateral shift in location of purlin true position	±5 mm
Deviation in difference of bearing levels of trusses or beams from the true difference	i) ±20 mm for trusses ii) For beams : Depth < 1800mm : ±6mm Depth > 1800mm : ±10mm
Deviation in sag in chords and diagonals of truss between node points	1/1500 of length in mm or 10mm whichever is smaller
Deviation in sweep of trusses, beams etc. in the horizontal plane	1/1000 of span in mm subject to a maximum of 10 mm

6.17.4 Crane Girders & Rails

Shift in the centre line of crane rail with respect to centre line of web of crane girder	±5 mm
Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point	±5 mm
Difference in alignment of crane rail in plan measured between any two points 2 metres apart along rail	±1 mm
Deviation in crane track with respect to Time gauge	
(a) For track gauges upto and Including 15 metres	±5 mm
(b) For track gauges more than 15 metres	± [5 + 0.25 (S-15)] where S in metres is true gauge
Deviation in the crane rail level at any point from true level	±1/1200 of the gauge distance or ±10mm whichever is less
Difference in the crane rail actual levels between any two points 2 metres apart along the rail length	±2 mm
Difference in levels between crane track Rails at	
(a) Supports of crane girders	±15 mm
(b) Mid span of crane girders	± 20 mm
Relative shift of crane rail surfaces at a	2 mm subject to grinding of

joint in plane and elevation	surfaces for smooth transition
Relative shift in the location of crane stops (end buffers) along the crane tracks with track gauge S in mm	1/1000 of track gauge S in mm subject to maximum of 20 mm

6.18 Clean up of Work site

During erection, the Contractor shall at all times keep the working and storage areas used by him free from accumulation of waste materials or rubbish. Before completion of erection, he shall remove or dispose of in a satisfactory manner all temporary structures, waste and debris and leave the premises in a condition satisfactory to the Employer's Representative.

6.19 Painting

6.19.1 General

After steel has been erected, all bare and abraded spots, rivet heads, field welds, bolt heads and nuts shall be spot painted with primer. Before paint is applied, the surface shall be dry and free from dust, dirt, scale and grease. All surfaces inaccessible after erection shall receive two coats of the approved paint before erection.

6.19.2 Surface Treatment

All the surfaces of steel work to be painted shall be thoroughly cleaned of all loose mill scale, rust, grease, dirt and other foreign matter. The workmanship shall generally conform to the requirements of IS 1477- Part I.

Oil and grease removal shall be carried out either by solvent cleaning or by using alkali type degreasing agents. To remove grease material the surface shall be cleaned with solvents containing emulsifier. After cleaning, the surface shall be washed with water. When the surface has cement pelter or salts, the cleaning shall be done with strong alkalies. After cleaning, water rinsing and subsequent passivation by dilute chromic acid rinsing shall be carried out to ensure that no traces of alkali is left on the surface. The procedure for cleaning by above mentioned methods shall be as per manufacturer's instructions.

Derusting and descaling of steel shall be carried out either manually, mechanically or chemically.

6.19.2.1 Manual or Hand Tool Cleaning

Loose mill scale, loose rust and loose paint shall be removed by wire brushing, scrapping, chipping, rubbing with abrasive paper or steel wool. This method shall not be employed when the surface has firmly adhering mill scale. After hand tool cleaning, the surface shall be rubbed with sand paper so as to ensure that no loose material exists and the surfaces shall be dusted off.

6.19.2.2 Mechanical Cleaning

Power Tool Cleaning

This shall be carried out by employing power operated wire brushes. Power tool cleaning shall be resorted to only if sand/shot blasting is not possible/permissible and high quality of surface preparation is required.

The surface prior to treatment shall have been cleaned of dust and grease and heavier layers of rust removed by chipping.

The powertool cleaning shall remove loose mill scale and rust by adopting very thorough scrapping, grinding and machine brushing. After the surfaces are cleaned by compressed air, it shall have a pronounced metallic sheen.

Flame Cleaning

Hard mill scale and rust shall be removed through Oxy- acetylene flame. The work shall be carried out by trained workmen to ensure that only mill scale is removed without heating the parent steel. The work shall be carried out carefully on welded surfaces so that the strength of weld is not affected due to heating.

6.19.2.3 Sand Blasting and Shot Blasting

Sand/shot blasting shall only be carried out after removal of grease, oil and other contaminants. The work shall be carried out by impinging under pressure of air, a jet of sharp sand or granulated steel (steel grits) on to the metal surface. The process shall ensure complete removal of rust and firmly adhering mill scale. Special care shall be taken on weld areas to remove flux and spatter. Blasting shall ensure an even colour of the surface and the surface shall have silver grey colour. Precautions shall be taken when sand or shot blasting of light gauge steel surfaces to ensure that buckling does not occur due to continuous impingement of sand or steel shots under high velocity.

Sand/shot blasting shall be adopted for structures which are exposed to corrosive conditions for which superior paint protection is to be adopted. The finished surfaces shall conform to the requirements of Sa 2.5 or Sa 3 as per Swedish Standard SIS-05-5900 as required.

As sand blasting causes dust nuisance, necessary clearance shall be obtained by the Contractor from the Competent authorities prior to commencing sand blasting.

6.19.2.4 Chemical Cleaning (Pickling)

The cleaning shall be done by pickling in sulphuric, hydrochloric or phosphoric acids. Pickling shall be carried out in accordance with detailed procedure as given in IS 6005.

Washing after pickling shall remove all traces of the acids. All work pieces shall be thoroughly inspected and in particular the inaccessible corners.

All surfaces shall be cleaned thoroughly as per manufacturers specification before application of primer.

6.19.3 Materials

6.19.3.1 Primer paint

Anti-corrosive primers shall be either lead based or lead free types. Red lead primer shall conform to IS 102 and red oxide zinc chrome primer shall conform to IS 2074.

6.19.3.2 Finish Paint

Epoxy primer and epoxy paint shall be of the type as specified from an approved manufacturer.

Chlorinated rubber based paint shall be of the manufacture as specified or any equivalent approved manufacture.

All the materials shall be of the best quality from an approved manufacturer. The Contractor shall obtain prior approval of the Employer's Representative for the brand of manufacture and the colour/shade prior to procurement for usage in the works.

Primer and finish paints shall be compatible with each other to avoid cracking and wrinkling. As such it is recommended that the primer and finish paint shall be from the same manufacturer.

The colour and shade shall be conforming to BIS Standards referred to in Appendix 'D' of IS 1477-Part II. To facilitate choosing the correct shade number from the alternatives available, the Contractor shall adopt trial painting in small patches in consultation with and as approved by the Employer's Representative.

All paint delivered to the fabrication shop/site shall be ready mixed, in original sealed containers, as packed by the manufacturer. Thinner shall not be permitted for usage unless specifically approved so by the Employer's Representative.

Paints shall be stirred thoroughly to keep the pigment in suspension.

The Contractor shall arrange for testing of paints as per relevant Indian Standards in an approved laboratory whenever the Employer's Representative requires the tests to be carried out for each batch of paints. Test results shall be submitted to the Employer's Representative for approval.

6.19.4 Workmanship

The type and the number of coats of the primer paint and finish paint shall be as specified.

Painting shall be carried out only on thoroughly dry surfaces.

No painting shall be done in frosty/foggy weather or when the humidity is high enough to cause condensation on the surface to be painted. Paint shall not be applied when the temperature of the surface to be painted is at 5deg.C or lower.

Primers shall adhere to the surface firmly and offer a key to the subsequent coats.

Workmanship shall generally conform to requirements specified in IS:1477-Part II.

It is essential to ensure that immediately after preparation of the surfaces, the first coat of primer paint shall be applied by brushing and working it well to ensure a continuous film. After the first coat becomes hard dry a second coat of primer shall be applied by brushing.

Structural steel surfaces shall be given the first coat of primer at shop and the second coat after it is erected in position. Further, any abraded surfaces of the first coat during transport from shop to site and during erection shall be provided with a touch-up coat of the primer.

The dry film thickness of each coat of primer shall be not less than 25 microns.

Application of finishing paints shall be carried out within the shortest possible time interval after primer since the primer coats are too thin to give adequate corrosion protection of the steel surface over a long duration.

Filler coats shall be applied to fill dents and to obtain a smooth finish wherever necessary. Only factory prepared filler suitable for steel work shall be used. Fillers prepared by whiting and linseed oil by craftsmen at site shall not be used. Application of filler shall be done with good `putty knife' and necessary skill. Filler applied shall be just sufficient to fill the depression or unevenness and it shall be restricted to the minimum. It shall be applied in thin layers. In filling depression or unevenness, as many coats as are necessary may be applied allowing each layer to dry hard. The hardened coat shall be cut down by wet rubbing before the subsequent coat is applied. Where necessary, filler coats shall be applied over the undercoats also.

Painting shall be carried out either by brushing or by spraying. The Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer.

After the second coat of primer is hard dry, the entire surface shall be wet rubbed cutting down to a smooth uniform surface. When the surface becomes dry, the undercoat of paint of optimum thickness shall be applied by brushing/spraying with minimum of brush marks. The coat shall be allowed to hard-dry. The under coat shall then be wet rubbed cutting down to a smooth finish, taking adequate care to ensure that at no place the undercoat is completely removed. The surface shall then be allowed to dry.

The first finishing coat of paint shall be applied by brushing or by spraying and allowed to hard-dry. The gloss from the entire surface shall then be gently removed and the surface dusted off. The second finishing coat shall then be applied by brushing or by spraying.

At least 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and shall be approved by the Employer's Representative, prior to applying the next coat.

Minimum dry film thickness of each coat of finish paint of synthetic enamel shall be 25 microns. Minimum dry film thickness of other finish paints shall be as specified in the respective item of work.

The thickness of film shall be measured by an Elcometer to be supplied by the Contractor. The Contractor shall calibrate the Elcometer frequently for different settings. Necessary calibrating accessories should be kept ready for calibration / testing of the Elcometer at any time.

Epoxy primer and epoxy paint shall be applied within the specified pot life all as per recommendations of the manufacturer.

Surfaces inaccessible after assembly shall receive two coats of primer prior to assembly.

Surfaces inaccessible after erection, including top surfaces of floor beams, supporting grating or chequered plate shall receive one additional coat of finish paint over and above the number of coats specified prior to erection.

Portion of steel members embedded/to be encased in concrete shall not be painted. Joints to be site welded shall have no shop paint for atleast 50mm from the welding zone. Similarly, the steel surfaces shall not be painted in areas where connection is by use of friction grip bolts. On completion of the joint, the surfaces shall received the painting as specified.

Maintenance painting of steel structures will become necessary if the painting already carried out shows signs of chalking, hairline cracking, deep checking, fine checking, peeling, blistering and rusting. It is essential that same quality of paint as specified earlier need be adopted to ensure compatibility. The general workmanship for maintenance painting shall conform as per Clause.7 of IS 1477 – Part II.

The Contractor shall provide suitable protection as necessary to prevent paint finishes from splashing on equipment, floors, walls, etc.

6.20 Method of Measurement

For the purpose of payment, the weight of the actual, completed structures shall be calculated from the approved drawings for different items of work. Contractor shall submit to Employer relevant material list containing weight of each item.

No allowance will be permitted for weights of rivets, bolts, washers, screws etc. in calculating the weight of the completed structure. No allowances will be permitted for galvanizing, welding or for rolling margins. One tonne for the purpose of payment shall mean One Metric Tonne i.e. 1000 kg.

The weight of a member made out of standard rolled sections such as beams, channels, angles, etc. shall be based on the weight of the member given in IS 808, without deducting for hole, notches, bevel cuts, etc. Where a component consists of a cut joist or channel, the full weight of the rolled section shall be considered only if more than half the depth of the section is used. Otherwise only half the section unit weight shall be taken. Deductions shall be made in the weight of gussets/plates including chequered plates for skew cuts, notches and openings of 900 sq.cm. or larger.

For gussets/plates used in trusses, bracings, columns, beams etc. the area shall be that of the minimum circumscribing rectangle, except as stated above.

The weight of any built-up member shall be separated into the weight of each component.

Erection bolts installed by erector may be left in position on completion of erection; however, no additional payment shall be made either for supply or use of such bolts. If erection bolts are removed after erection is

complete, holes shall be plug welded and ground smooth. No extra payment shall be made for such plug welding.

Painting work shall not be measured separately, if primer painting and/or primer and finish painting is deemed to be included in the scope of the item of work of fabrication and erection of structural steel since the rate per tonne of steel is deemed to include for painting as specified.

In cases where primer and/or finish painting work as specified is carried out on erected structural steel executed by a different agency, the method of measurement for painting shall be on the basis of tonnage of steel erected. For this purpose, the tonnage of erected steel as certified for payment to the different agency shall be considered as the basis and no measurement will be carried out separately.

6.21 Galvanising of Structural Steel

6.21.1 Galvanising Plant

Prior approval shall be obtained from Employer / Engineer if galvanising is proposed to be carried out outside Contractor's plant.

6.21.2 Workmanship

After all shop work is complete, all structural materials shall be punched with the erection mark and be hot-dip galvanised. Before galvanising, the steel shall be thoroughly cleaned of any paint, grease, rust, acid or alkali or such other foreign matters as are likely to interfere with the galvanising process or with the quality and durability of the zinc coating. Pickling shall be very carefully done and shall be proper.

The weight of the zinc coating shall be at least 0.610 kg/sq.m unless specified otherwise. Stub members and members for grillage type footing shall have heavier zinc coating not less than 0.80 kg/sq.m.

The galvanised surface shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth, and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel, globules, spiky de S:2633 unless specified otherwise.

All galvanised members shall be treated with Sodium dichromate solution or an approved equivalent after galvanising, so as to prevent white storage stains.

Galvanising of each member shall be carried out in one complete immersion. Double dipping shall not be permitted. However, in case of members over 7.5 M long, the Contractor shall take prior approval of Engineer for double dipping. When the steel section is removed from the galvanising kettle, excess spelter shall be removed by 'bumping'.

Wherever galvanised bolts, nuts locknuts, washers, accessories etc. are specified, they shall be hot-dip galvanised. Spring washers shall be electro-galvanised. Excess spelter from bolts, nuts, etc. shall be removed by centrifugal spinning. Rechasing of bolt threads after galvanising shall not be permitted. Nuts, however, may be tapped, but not to cause appreciable rocking of the nuts on the bolts. Readily available GI nuts, bolts and washers conforming to galvanising requirements may also be used.

Defects in certain members indicating presence of impurities in the galvanising bath in quantities larger than that permitted by the specifications, or lack of quality control in any manner in the galvanising plant, shall render the entire production in the relevant shift liable to rejection.

Contractor shall ensure that galvanising is not damaged in transit. In the event of occurrence of any damages Contractor shall at his own cost adopt scrapping and regalvanising the member to satisfy the specific requirements.

End of Section 6

SECTION 7

WATER SUPPLY AND SANITARY WORKS

SECTION 7

WATER SUPPLY AND SANITARY WORKS

7.1 Applicable Codes

The following standards and codes are made a part of this Employer's Requirement. All standards, codes of practice referred to herein shall be the latest editions including all official amendments and revisions.

IS : 210	:	Specification for grey iron castings.
IS : 269	:	Specification for 33 ordinary grade portland cement.
IS : 383 concrete.	:	Specification for coarse and fine aggregates from natural sources for
IS : 432 steel	:	Specification for mild steel and medium tensile steel bars and hard drawn wire for concrete reinforcement.
IS : 456	:	Code of Practice for plain and reinforced concrete.
IS : 458	:	Precast Concrete Pipes (with and without reinforcement) - Specification
IS : 516	:	Methods of tests for strength of concrete
IS : 554	:	Pipe threads where pressure tight joints are made on the threads – Dimensions, Tolerances & Designation
IS : 651	:	Specifications for Salt glazed stoneware pipes and fittings.
IS : 774	:	Flushing Cisterns for water closets and urinals (Other than plastic cisterin) - Specifications
IS : 775	:	Specifications for Cast iron brackets and supports for wash basins and sinks.
IS : 781	:	Specifications for Cast Copper along screw - down bib taps and stop taps for water services.
IS : 783	:	Code of practice for laying of concrete pipes.
IS : 1068	:	Electroplated coatings of nickel plus chromium & copper plus nickel plus chromium.
IS : 1077	:	Specification for common burnt clay building bricks
IS : 1786	:	Specification for high strength deformed steel bars and wires for concrete reinforcement
IS : 1239	:	Mild steel tubes (Part I) and mild steel tubulars and other wrought steel pipe fittings (Part II)
IS : 1536	:	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage.
IS : 1626	:	Asbestos cement building pipes, gutters and fittings (spigot and socket types).
IS : 1703 purposes.	:	Copper Alloy float valves (horizontal plunger type) for water supply
IS : 1726	:	Specifications for Cast iron manhole covers and frames.
IS : 1729	:	Cast iron/Ductile iron drainage pipes and pipe fittings for over ground non-pressure pipeline socket & spigot series.
IS : 1742	:	Code of practice for buildings drainage
IS : 2116	:	Specification for sand for masonry mortars
IS : 2212	:	Code of practice for brickwork

IS : 2250	:	Code of practice for preparation and use of masonry mortars
IS : 2326	:	Specifications for Automatic flushing cisterns for urinals
IS : 2470	:	Code of practice for installation design criteria and construction of septic tanks (Parts I & II)
IS : 2556	:	Vitreous sanitary appliances (Part I to Part XV)
IS: 2963	:	Specification for copper alloy waste fittings for wash basins and sinks
IS: 3006	:	Specification for chemically resistant glazed stoneware pipes and fittings
IS: 3311	:	Specification for Waste plug and its accessories for sinks and wash basins
IS: 5455	:	Specification for cast iron steps for manholes
IS: 4127	:	Code of Practice for laying of glazed stoneware pipes
IS : 3495	:	Methods of tests of burnt clay building bricks
IS : 4111	:	Code of practice for ancillary structures in sewerage system manholes
IS : 5382	:	Specification for rubber sealing rings for gas mains, water mains and sewers
IS : 5329	:	Code of practice for sanitary pipe work above ground for buildings
IS : 5434	:	Specification for Non-ferrous alloy bottle traps for marine use

7.2 Sanitary Installation

The work shall be carried out complying in all respects with any specific requirements of the local body in whose jurisdiction the work is situated, and as approved by the Employer's Representative.

Any damage caused to the building, or to installations therein, either due to negligence on the part of the Contractor, or due to actual requirements of the work, shall be made good and the building or the installation shall be restored to its original condition by the Contractor.

All sanitary and plumbing work shall be carried out by licensed plumbers.

All sanitary appliances including sanitary fittings, fixtures, toilet requisites shall be of size, and design as approved by the Employer's Representative.

All white glazed porcelain fixtures, such as wash basin, sink drain board, water closet pan, urinal, `P' trap etc. shall have hard durable white glazed finish. They shall be free from cracks and other glazing defects. No chipped porcelain fixtures shall be used.

Joints between iron and earthenware pipes shall be made perfectly air and water tight by caulking with neat cement mortar.

7.3 Indian Type Water Closet

This shall be the long pan pattern with separate footrests made of white glazed earthenware, white glazed vitreous china or of white glazed fire clay. The general requirements shall conform to IS:2556 (Parts III and X). Each pan shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flush type. The flushing rim and inlet shall be of the self draining type. It shall have a weephole at the flushing inlet to the pan. The flushing inlet shall be in the front, unless otherwise approved by the Employer's Representative. The inside of the bottom of pan shall have sufficient slope from the front towards the outlet and the surface shall be uniform and smooth enable easy and quick disposal while flushing. The exterior surface shall be unglazed and sufficiently rough or grooved at right angles to the axis of the outlet. Pans shall be provided with a

trap `P' or `S' type with a minimum 50 mm water seal and 50 mm dia. vent horn. Pan shall be laid at the correct location and level over a bed of lime concrete using brick aggregates (1 part lime mortar to 2 parts brick bats with lime mortar to 2 parts of sand) or cement-sand admixture as specified in the drawings.

7.4 European Type Water Closet

Water closets shall be either of white glazed earthenware, white grazed vitreous china or white glazed fire clay as specified and shall be of "Siphonic Wash down type" conforming to IS.2556 (Part VIII). The closets shall be of one piece construction with approved plastic/bakelite seat and cover. Each water closet shall have 4 fixing holes having a minimum diameter of 6.5 mm for fixing to floor and shall have an integral flushing rim of suitable type. It shall also have an inlet of supply horn for connecting the flush pipe. The flushing rim and inlet shall be of the self-draining type. The water closet shall have a weephole at the flushing inlet. Each water closet shall have an integral trap with either "S" or "P" outlet with at least 50 mm water seal. The water closets shall have an antisiphonage 50 mm dia. vent horn on the outlet side of the trap. The inside of water closets and traps shall be uniform and smooth in order to ensure in efficient flush. The serrated part of the outlet shall not be glazed externally. The water closet when sealed at the bottom of the trap in line with the back plate, shall be capable of holding not less than 10 litres of water between the normal water level and the highest possible water level of the water closet installed.

7.5 Urinals

Urinals shall be of the bowl pattern, either flat back or angle back type lipped in front. They shall be of white glazed earthenware, white glazed vitreous china or white glazed fire clay, and of size as specified conforming to IS.2556 (Part VI). The urinals shall be of one piece construction. Each urinal shall be provided with not less than two fixings holes of a minimum dia. of 6.5 mm on each side. Each urinal shall have an integral flushing box rim of suitable

type and inlet or supply horn for connecting the flush pipe. The flushing rim and inlet shall be of the self-draining type. It shall have a weephole at the flushing inlet of the urinal. At the bottom of the urinal, an outlet horn for connecting to an outlet pipe shall be provided. The exterior of the outlet horn shall not be glazed and the surface shall be provided with grooves at right angles to the axis of the outlet to facilitate fixing to the uniform and smooth throughout to ensure efficient flushing. The bottom of pan shall have sufficient slope from the front, towards the outlet such that there is efficient draining of the urinal. The waste fittings shall be chromium plated.

7.6 Wash Basins

(a) Wash basins shall be of white glazed earthenware, white glazed vitreous china or white glazed fire clay as approved by the Employer's Representative and conforming to IS.2556

Type	Size
Flat Back	630 x 450 mm
Flat Back	550 x 400 mm

(b) Wash basins shall be of one piece construction, including a combined overflow. All internal angles shall be designed so as to facilitate cleaning. Each shall have a rim sloping inside towards the bowl on all sides except skirting at the back. Basins shall be provided with single or double tap holes as approved. The tap holes shall be square. A suitable tap hole button shall be supplied if one tap hole is not required in installation. Each basin shall have a circular waste hole to which the interior of basin shall drain. The waste hole shall be either rebated or bevelled internally with diameter of 65 mm at top and a depth of 10 mm to suit a waste plug having 64 mm diameter. Each basin shall be provided with a non-ferrous 32 mm waste fittings. Stud slots to receive the brackets on the under side of the wash basins shall be suitable for a bracket with stud not exceeding 13 mm diameter, 5 mm high and 305 mm from the back of basin to the centre of the stud. The stud slots shall be of

depth sufficient to take 5 mm stud. Every basin shall have an integral soap holder recess or recesses which shall fully drain into the bowl. The position of the chain stay-hole shall not be lower than the overflow slot. A slot type of overflow having an area of not less than 5 sq.cm. shall be provided and shall be so designed as to facilitate cleaning of the overflow. The Employer's Requirements for waste plug, chain and stay shall be the same as given for sinks.

(c) All the waste fittings shall be chromium plated. Bottle trap shall conform to IS. 5434. The chromium plating shall be of service grade No. 2 conforming to IS.1068.

7.7 Sinks

(a) The sinks shall be of white glazed earthenware, white glazed vitreous china or white glazed fire clay as approved by the Employer's Representative conforming to IS.2556 (Part V) and shall be of the following sizes:

450 x 300 x 150 mm
600 x 450 x 200 mm

(b) They shall be of one piece construction, including a combined overflow. The floor of the sink shall gently slope towards the outlet. The outlet shall in all cases be suitable for waste fittings having flange of 64 mm diameter and the waste hole shall have a minimum diameter of 65 mm at the bottom to suit the waste fittings. The waste hole shall be either rebated or bevelled having a depth of 10 mm. Each sink shall be provided with a non-ferrous 40 mm dia. waste fitting. The sink shall have overflow of the weir type and the inverts shall be 30 mm below the top edge. Each sink shall be provided with a waste plug, of suitable dia. chain and stay. The plug shall be of rubber or other equally suitable material and shall be water tight when fitted. Plug chains shall be of brass wire chromium plated. It shall have an overall length from the collar to the stay of not less than 300 mm. There shall be a triangular or D shackle at each end, one of which shall be brazed to the plug and the other securely fixed to the stay. The 150 mm long shank of the waste shall be threaded conforming to the requirements of IS.2556 for sinks only. The waste fittings and plug fittings shall be chromium plated. The chromium plating shall be of service grade No.2 conforming to IS.1068.

7.8 Flushing Cisterns

The flushing cisterns shall be automatic or manually operated, high level or low level, as approved by the Employer's Representative. For water closets and urinals high level cistern is intended to operate with minimum height of 125 cm and a low level cistern a maximum height of 30 cm between the top of the pan and the underside of the cistern. They shall be of cast iron, glazed earthenware, or pressed steel complying iron, glazed requirement of IS.774. Automatic flushing cistern for urinals shall conform to IS.2326.

7.9 Cast Iron Soil Waste and Vent Pipes and Fittings

All cast iron pipes and fittings shall be of uniform thickness with strong and deep sockets, free from flaws, air holes, cracks, sand holes and other defects and conform to IS.1536 . The diameter approved shall be internal diameter of pipe. The pipes and fittings shall be true to shape, smooth and cylindrical and shall ring clearly when struck over with a light hand hammer. All pipes and fittings shall be properly cleaned of all foreign material before being fixed.

All plug bends of drainage pipes shall be provided with inspection and cleaning caps, covers, which shall be fixed with nuts and screws. Pipes shall be fixed to the wall by W.I. or M.S. holder bat clamps, unless projecting ears with fixing holes are provided at socket end of pipe. The pipes shall be installed, truly vertical or to the lines and slopes as indicated. The clamps shall be fixed to the walls by embedding their hooks in cement concrete blocks (1:2:4) 10 cm x 10 cm making necessary holes in the walls at proper places. All holes and breakages shall be made good. The clamps shall be kept 25 mm clear of the finished face of the walls to facilitate cleaning and painting of pipes.

The annular space between the socket and spigot shall be filled with a gasket of hemp or spun yarn soaked in neat cement slurry. The joint shall then be filled with stiff cement mortar 1:2 (1 cement: 2 fine sand) well pressed with caulking tool and finished smooth on top at an angle of 45°. The joint shall be kept wet for not less then 7 days by tying a piece of gunny bag kept moist. Joints shall be perfectly air tight as well as water tight.

C.I. pipes and fittings which are exposed shall be first cleaned and then painted with a coat of red leadprimer. Two coats of zinc paint with white base and mixed with pigment of required colour to get the approved shade shall be given over the base primer coat.

The thickness of fittings and their socket and spigot dimensions shall conform to the thickness and dimensions approved for the corresponding sizes of straight pipes.

The connection between the main pipe and branch pipes shall be made by using branches and bends with access for cleaning. Floor traps shall be provided with 25 mm dia. puff pipe where the length of the waste is more than 1800 mm or the floor trap is connected to a waste stack through bends.

All cast iron pipes and fittings including joints shall be tested by a smoke test to the satisfaction of the Employer's Representative and left in working condition after completion. The smoke test shall be carried out as stated under:

Smoke shall be pumped into the pipe at the lowest and from a smoke machine which consists of a bellow and a burner. The material usually burnt is greasy cotton waste which gives out a clear pungent smoke which is easily detectable by sight as well as by smell if there is a leak at any point of the pipeline.

Water test and air test shall be conducted as stipulated in IS.5329.

7.10 Asbestos Cement (A.C) Pipes and Fittings

All A.C. soil, waste, vent pipes, and fittings shall conform to IS.1626. The pipes shall have spigot and socket ends. These shall be composed of an inert aggregate consisting of clean asbestos fibre cemented together by ordinary portland cement conforming to IS.269, or portland blast furnace slag cement conforming to IS.455. No organic material shall be added to the composition.

The pipes shall be straight and the ends of the pipes and fittings shall be finished square to their axes. The finished pipes and fittings shall be true and smooth, their inner and outer surfaces shall be concentric. They shall be in all respects sound, homogenous and free from impurities or other imperfections.

The permissible tolerance on the thickness and external dimensions of pipes and fittings including hydraulic test pressure of the pipes and fittings shall conform to IS.1626.

All AC pipes and fittings shall be of approved make and with necessary accessories, wherever required. The diameter wherever approved for pipes and fittings shall be clear internal diameter. All gaps between pipes and fittings and walls shall be filled with cement mortar 1:3 neatly finished. All pipes and fittings shall be supported with standard fixing brackets.

The annular space between the socket and spigot shall be filled with a gasket of hemp of spun yarn soaked in tar. The joint shall then be filled with stiff cement mortar 1:2 (1 cement : 2 fine sand) well pressed with caulking tools and finished smooth on top with neat cement paste at an angle of 45º. The joint shall be kept wet for not less than 7 days by tying a piece of gunny bag kept moist. Joints shall be perfectly air-tight as well as water-tight.

Pipes and fittings shall be tested with a smoke test as approved in Clause 7.9.

7.11 Galvanised Mild Steel (G.I) Pipes

The pipes shall be galvanised mild steel welded pipes and seamless screwed and sockets tubes conforming to the requirements of IS.1239, for medium grade. They shall be of the diameter (nominal bore) approved. The sockets shall be designated by the respective nominal bores of the pipes for which they are intended. The pipes and sockets shall be finished neatly, well galvanised on both inner and outer surfaces, and shall be free from cracks, surface flaws, laminations and other defects. All screws, threads shall be clean and well cut. The ends shall be cut cleanly and square with the axis of the tube.

All screwed tubes and sockets shall have pipe threads conforming to the requirements of IS.554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

The fittings shall be of malleable cast iron or mild steel tubes complying with all the appropriate requirements as approved for pipes. The fittings shall be designated by the respective nominal bores of the pipes for which they are intended. The fittings shall have screw threads at the ends conforming to the requirements of IS.554.

Female threads on fittings shall be parallel and male threads (except on running nipples and collars of unions) shall be tapered.

The pipes and fittings shall be inspected at site before use to ascertain that they conform to the specification. The defective pipes shall be rejected. Where the pipes have to be cut or rethreaded, the ends shall be carefully filled out so that no obstruction to bore is offered. The ends of the pipes shall then be threaded conforming to the requirements of IS.554 with pipe dies and taps carefully in such a manner as will not result in slackness of joints when the two pieces are screwed together. The taps and dies shall be used only for straightening bent and damaged screw threads and shall not be used for turning of the threads so as the make them slack, water tight joint. The screw- thread of pipes and fittings shall be protected from damage until they are fitted.

The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped around the screwed end of the pipe.The end shall then be screwed in the socket, tee, etc., with the pipe wrench. Care should be taken that all pipes and fittings are properly jointed so as to make the joints completely water tight and pipes are kept at all times free from dust and dirt during fixing. Burrs from the joint shall be removed after screwing. After laying, the open ends of the pipes shall be temporarily plugged to prevent access of soil or any other foreign matter.

Any threads exposed after jointing shall be painted or in the case of underground piping thickly coated with approved anticorrosive paint to prevent corrosion.

For internal work the galvanized iron pipes and fittings shall run on the surface of the walls or ceiling (not in chase) unless otherwise specified. The fixing shall be done by means of standard pattern holder bat clamps, keeping the pipes about 1.5 cm clear of the wall. Pipes and fittings shall be fixed truly vertical/horizontal. When it is found necessary to conceal the pipes, chasing may be adopted or pipes fixed in the ducts of recesses etc. provided there is sufficient space to work on the pipes with the usual tools. The pipes shall not ordinarily be buried in walls or solid floors. Where unavoidable, pipes may be buried for short distances provided adequate protection is given against damage, but the joints in pipes shall not beburied. M.S. pipe sleeve shall be fixed at a place where a pipe is passing through a wall or floor for reception of the pipe and to allow freedom for expansion/contraction and other movements/maintenance. In case the pipe is embedded in walls or floors it should be painted with anti-corrosive bitumastic paint of approved quality. The pipe should not come in contact with lime mortar or lime concrete as the pipe is affected by lime. Under the floors the pipes shall be laid in layer of sand filling or as approved by the Employer's Representative.
G.I. pipes with socket and spigot ends shall be provided with lead caulked joints wherever specified and the joints shall conform to the requirements of IS.3114.

The work of excavation and backfilling shall be done true to line and gradient in accordance with general Employer's Requirements for earthworks in trenches for pipes laid underground.
The pipes shall be laid on a layer of 10.0 cm sand and filled upto 15 cm above the pipes. A sand cushion of 15cm on either side of the pipe shall also be provided. The remaining portion of the trench shall then be filled with excavated earth. The surplus earth shall be got rid of as directed. when excavation is done in rock the bottom shall be cut deep enough to permit the pipes to be laid on a cushion of sand 75 mm minimum.

The pipes and fittings after they are laid and jointed shall be subjected to hydrostatic pressure test as approved by the Employer's Representative and shall satisfactorily pass the test. Pipe line system shall be tested in sections as the work proceeds, keeping the joints exposed for inspection. Pipes shall be slowly and carefully charged with water allowing all air to escape. All draw off taps shall then be closed and water pressure gradually raised to test pressure. Care shall be taken to ensure that pressure gauge is accurate and preferably should have been recalibrated before the test. Pump used having been stopped, the section of the pipeline shall maintain the test pressure for at least half an hour. Any joints or pipes found leaking shall be removed and replaced by the Contractor.

The G.I. pipe line shall be cut to the required length at the position where the meter and stop cock are required to be fixed. The ends of the pipes shall be threaded. The meter and stop cock shall be fixed in position by means of connecting pipe, G.I. nuts, sockets, etc. The stop cock shall be fixed near the inlet of the water meter. The paper disc inserted in the ripples of the meter shall be removed and meter installed exactly horizontally or vertically and with the arrow cast on the body of the meter pointing in the direction of flow. Care shall be taken that the factory seal of the meter is not disturbed. Whenever the meter is to be fixed to a newly fitted pipe line, the pipe line will have to be completely washed before fixing the meter. For this purpose, a connecting piece of pipe equal to the length of the meter is to be fixed on the new pipe line. The water shall be allowed to flow completely to wash the pipe line and then the meter installed as described above by replacing the connecting piece.

7.12 Stoneware pipes and fittings

All pipes with spigot and socket ends shall conform to IS.651/3006 and shall be of grade `A'. These shall be sound, free from visible defects such as fine cracks or hair cracks. The glaze of the pipes shall be free from crazing. The pipes shall give a sharp clear note when struck with a light hammer.

The following information shall be clearly marked on each pipe and fitting :

(a) Internal diameter;
(b) Grade;
(c) Date of manufacture;
(d) Name of manufacturer or his registered trade-mark or both.

All pipes and fittings shall have ISI mark.

Jointing of GSW pipes and fittings shall be done as per the requirements of the following Employer's Requirements and the relevant BIS. After jointing, extraneous material if any, shall be removed from the inside of the pipes and fittings and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS : 5382.

7.12.1 Spigot and Socket Joint (Cement Joint)

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. In each joint, spun yarn soaked in neat cement slurry or tarred gasket shall be passed around the joint and inserted in it by means of a caulking tool. More skeins of yarn or gasket shall be added if necessary and shall be well caulked. Yarn or gasket so rammed shall not occupy more than one- fourth of the depth or socket.

Cement mortar (1:1) shall be slightly moistened and carefully inserted by hand into the remaining space of the joint after caulking of yarn or gasket. The mortar shall than be caulked into the joint with a caulking tool. More cement mortar shall be added until the space of joint has been completely filled with tightly caulked mortar. The joint shall then be finished of neatly outside the socket at an angle of 45 degrees.

The cement mortar joints shall be cured at least for seven days before testing.
The approximate quantity of cement required for each joint for certain common sizes of pipes are give below for guidance :

Nominal diameter of pipe (mm)	Cement (kg)
150	1.5
200	2.0
250	2.5
300	3.25
350	4.5
400	5.5
450	6.5

7.12.2 Spigot and Socket Joint (Bituminous Joint)

The general requirements for this type of joint shall be as specified in 13.12.1 The material for jointing shall consist of composition of asphalt and sand in the ratio of 1:7. Asphalt and sand shall be boiled together and filled into the socket in a molten state with the aid of special moulds.

7.12.3 Spigot and Socket Joint (Rubber Ring Joint)

The pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The rubber rings conforming to IS : 5382 shall be used, and the manufacturer's instructions shall be deemed to form a part of this Employer's Requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

7.12.4 Cleaning of Pipes

As soon as a stretch of GSW pipes has been laid complete from manhole to manhole or for a length as approved by the Employer's Representative, the Contractor shall run through the pipes both backward and forward a double disc or solid or closed cylinder 50 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipeline shall be securely closed as approved by the Employer's Representative to prevent entry of mud or silt etc.

If as a result of the removal of any obstruction the Employer's Representative considers that damages may have been caused to the pipe lines, he shall be entitled to order the length to be tested immediately. Should such test prove unsatisfactory the Contractor shall repair the pipeline and carry out such further tests as are required by the Employer's Representative.

It shall also be ascertained by the Contractor that each length from manhole to manhole or the length as approved by the Employer's Representative is absolutely clear and without any obstruction by means of visual examination of the interior of the pipeline suitably illuminated by projected sunlight or otherwise.

After laying and jointing of GSW pipes is completed the pipe line shall be tested as per the following Employer's Requirements and as approved by the Employer's Representative. All equipment for testing at work site shall be supplied and erected by the Contractor. Water for testing of pipeline shall be arranged by him. Damage during testing shall be the Contractor's responsibility and shall be rectified by him to the full satisfaction of the Employer's Representative. Water used for test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Employer's Representative and before backfilling the trenches, the entire section of the sewer or storm water drain shall be proved by the Contractor to be water tight. Before commencing the hydraulic test, the pipelines shall be filled with water and maintained full for 24 hours by adding water, if necessary, under a head of 0.6 m of water. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any, and filling the system with water. A knuckle bend shall be temporarily jointed at the top end and a sufficient length of vertical pipe jointed to it so as to provide the required test head; or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation. The pipeline shall be subjected to a test pressure of at least 2.5 m head of water at the highest point of the section under test. The tolerance of two litres per centimeter of diameter per kilometer may be allowed during a period of 10 minutes. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

If any damage is caused to the pipeline during the execution of work or while cleaning/testing the pipeline as specified. The Contractor shall be held responsible for the same and shall replace the damaged pipeline and re-test the same to the full satisfaction of the Employer's Representative.

Water for testing of pipeline shall be arranged by the Contractor.

7.13 Stop Cock and Bib Cock

A bibcock (bibtap) is a draw off tap with a horizontal inlet and free outlet and stopcock (stop tap) is a valve with a suitable means of connections for insertion in a pipe line for controlling or stopping the flow. They shall be of specified size and shall be of the screw down type. The closing device should work by means of a disc carrying a renewable non-metallic washer, which shuts against water pressure on a seating at right angles to the axis of the threaded spindle which operates it. The handle shall be either crutch or butterfly type securely fixed to the spindle. The cocks shall open in anti-clockwise direction. When the bib cocks and stop cocks are required to be chromium plated, the chromium plating shall be of service Grade No. 2 conforming to IS.1068. in finish and appearance, the plated articles shall be free from plating defects such as blisters, pits, roughness and shall not be stained or discoloured.

These fittings shall be of brass heavy class, chromium plated (C.P) and of approved manufacture and pattern with screwed of flanged ends as specified. The fittings shall in all respects comply with the requirements of IS.781. The standard size of brass fittings shall be designated by the nominal bore of the pipe to which the fittings are attached. A sample of each kind of fitting shall be approved by the Employer's Representative and all supplies made according to the approved samples.

All cast fittings shall be sound and free from laps, blow holes and fittings, both internal and external surfaces shall be clean, smooth and free from sand etc. Burning, plugging stopping or patching of the casting shall not be permitted. The bodies, bonnets, spindles and other parts shall be truly machined and when assembled the parts shall be axial, parallel and cylindrical with surfaces smoothly finished. The area of the waterway of the fittings shall not be less than the area of the nominal bore.

The fittings shall be fully examined and cleared of all foreign matter before being fixed. The fittings shall be fitted in the pipe line in a workman like manner. The joints between fittings and pipes shall be made leak- proof. The joints and fittings shall be leak proof when subjected to a pressure test approved by the Employer's Representative and the defective fittings and joints shall be replaced or redone.

7.14 Soak Pit

Soak pit shall be constructed at the location specified by the Employer's Representative. Earthwork excavation shall be carried out to the exact dimensions. Brick masonry lining with open joints shall be constructed in the pit upto 150 mm below the outlet pipeline. Brick masonry in cement mortar 1:6 shall be constructed above this level upto ground. Well burnt brick aggregates of nominal size 40 mm to 80 mm and coarse sand shall be filled within the chamber. Construction of pit lining and filling of the brick ballast shall progress simultaneously.

7.15 Manholes

7.15.1 Location

Manholes shall be constructed at places approved by the Employer's Representative.

7.15.2 Excavation

Excavation, shoring, dewatering etc. for the pits of manholes, laying of pipes and fittings/specials shall be done in accordance with Employer's Requirements described elsewhere in the document.

7.15.3 Bed Concrete

The bed concrete for manholes shall be done in accordance with Employer's Requirements described elsewhere in the document.

7.15.4 Bricks

Bricks used for construction of manholes shall conform to the relevant Indian Standards. They shall be sound, hard, homogeneous in texture, well burnt in kiln without being vitrified, table moulded, deep red, cherry or copper coloured, of regular shape and size and shall have sharp and square and parallel faces. The bricks shall be free from pores, chips, flaws or humps of any kind. Bricks containing ungrounded particles and/or which absorb water more than 1/6th of their weight when soaked in water for twenty-four hours shall be rejected. Over burnt or under burnt bricks shall be liable to rejection. The bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 50 kg/sq.cm. unless otherwise noted in drawings. The class and quality requirements of bricks shall be as laid down in IS : 1077.

The size of the brick shall be 23.0 x 11.5 x 7.5 cm. unless otherwise specified; but tolerance upto 3 mm in each direction shall be permitted. Only full size brick shall be used for masonry work. Brick bats shall be used only with the permission of Employer's Representative to make up required wall length or for bonding. Sample bricks shall be submitted to the Employer's Representative for approval and bricks supplied shall conform to approved samples. If required by the Employer's Representative, brick sample shall be tested as per IS : 3495 by Contractor. Bricks rejected by the Employer's Representative shall be removed from the Site within 24 hours.

7.15.5 Cement Mortar

Mortar for brick masonry shall be prepared as per IS : 2250. Manholes shall be constructed in brick masonry with cement mortar (1:2) unless otherwise specified. Gauge boxes for sand shall be of such dimensions that one bag containing 50 kg. of cement forms one unit. The sand shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be as approved by the Employer's Representative. If required by the Employer's Representative sand shall be thoroughly washed till it is free of any contamination.

For preparing cement mortar, the ingredients shall first be mixed thoroughly in dry conditions. Water shall then be added and mixing continued to give a uniform mix of required consistency. Cement

mortar shall be used within 25 minutes of mixing. Mortar left unused in the specified period shall be rejected.

The Contractor shall arrange for tests on mortar samples if so required by Employer's Representative. Retempering of mortar shall not be permitted.

7.15.6 Brick Masonry

All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. The cement mortar for brick masonry work of manholes shall be in the proportion specified in 13.15.5. Brick work 230 mm thick and over shall be laid in English Bond unless otherwise specified. 115 mm thick brick work shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Bricks shall be laid with frogs uppermost.

All brickwork shall be plumb and square unless otherwise shown on drawing and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be levelled. The thickness of brick courses shall be kept uniform. For walls of thickness greater than 230 mm both faces shall be kept in vertical planes unless otherwise specified. All interconnected brickwork shall be carried out at nearly one level (so that there is uniform distribution of pressure on the supporting structure) and no portion of the work shall be left more than one course lower than the adjacent work. Where this is not possible, the work shall be raked back according to bond (and not saw toothed) at an angle not exceeding 45 degrees. But in no case the level difference between adjoining walls shall exceed 1.25 M. Workmanship shall conform to IS : 2212.

Brick shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 12 mm by raking tools daily during the progress of work when the mortar is still green, so as to provide a proper key for the plastering to be done. When plastering is not required to be done, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top. If mortar in the lower courses has begun to set, the joints shall be raked out to a depth of 12 mm before another course is laid.

7.15.7 Cement Plaster

All joints in masonry shall be raked to a depth of 12 mm with hooked tool made for the purpose when the mortar is still green and in any case within 48 hours of its laying. The surface to be rendered shall be washed with fresh clean water free from all dirt, loose material, grease etc. and thoroughly wetted for 6 hours before plastering work is commenced. Concrete surfaces to be rendered will however be kept dry. The wall should not be too wet but only damp at the time of plastering. The damping shall be uniform to get uniform bond between the plaster and the wall.

The proportion of the cement mortar shall be as approved on relevant drawings. Cement shall be mixed thoroughly in dry condition and then just enough water added to obtain a workable consistency. The quality of water, sand and cement shall be as per relevant I.S. The mortar thus mixed shall be used immediately and in no case shall the mortar be allowed to remain for more than 25 minutes after mixing with water.

Curing of plaster shall be started as soon as the applied plaster has hardened enough so as not to be damaged. Curing shall be done by continuously applying water in a fine spray and shall be carried out for at least 7 days.

Plastering shall be done on both faces of brick masonry in cement mortar (1:2) and 20 mm thick unless otherwise specified.

Plastering work shall be carried out in two layers, the first layer being 14 mm thick and the second layer being 6 mm thick. The first layer shall be dashed against the prepared surface with a trowel to obtain an even surface. The second layer shall then be applied and finished leaving an even and uniform surface, trowel finished unless otherwise approved by the Employer's Representative.

7.15.8 Cement Concrete Channel

The channel for the manhole shall be constructed in cement concrete of M15 grade. Both sides of the channel shall be taken up to the level of the crown of the outgoing sewer. They shall be benched up in concrete and rendered in cement mortar (1:1) of 20 mm thickness and formed to a slope of 1 in 12 towards the channel.

7.15.9 Pipe Entering or Leaving Manhole

Whenever a pipe enters or leaves a manhole, bricks on edge must be cut to a proper form and laid around the upper end of the pipe so as to form an arch. All around the pipes, there shall be a joint of cement mortar (1:2) 13 mm thick between it and the bricks.

7.15.10 Cast Iron Steps

Cast iron steps shall be as per IS : 5455. The steps shall be of grey cast iron of grade 15 as per IS : 210. The steps shall be clean, well cast and they shall be free from air and sand holes, cold shuts and warpings. The portion of the step which projects from the wall of the manhole shall have a raised chequered design to provide an adequate non-slip grip. C.I. steps shall weigh not less than 4.5 kg each and shall be of 150 mm x 375 mm overall dimensions. These steps shall be coated with a black bituminous composition. The coating shall be smooth and tenacious. It shall not flow when exposed to a temperature of 63 degrees C and shall not be brittle as to chip of at temperature of 0 degree C.

Where the depth of invert of manhole exceeds 800 mm, cast iron steps of approved pattern shall be fixed in the brick work at the interval of 300 mm vertically and staggered at 380 mm horizontally centre to centre. In case of pipe diameter greater than 600 mm, box type C.I. steps weighing 19 kg each shall be provided at 300 mm vertically in channel of manhole.

7.15.11 Frame and Covers

Frame and covers for manholes shall be of required type and dimensions as per the relevant drawings prepared by the Contractor. Following information shall be clearly marked on each cover.

Year of manufacture,
Identification mark of the purchaser,
SEWERS/SWD,
Arrow showing direction of flow

(a) Cast Iron Frame and Cover

The cast iron frame and cover shall be of grey cast iron as per IS : 1726. The general requirements for casting and coating of CI frame and cover shall be as specified for CI steps in Clause 7.15.10. The covers shall have a raised chequered design to provide an adequate non-slip grip. The rise of the chequer shall be not less than 4 mm. The locking device for the cover shall be provided as approved by the Employer's Representative. The CI covers for the load test shall be selected at one for every lot of fifty or part thereof for each type and size manufactured and as approved by the Employer's Representative. The frame shall be fixed in cement concrete of M15 grade all round and finished with neat cement. The manhole frame shall have 560 mm diameter clear opening and shall weigh not less than 208 kg. including cover. In case of rectangular CI frame and cover of 900 mm x 600 mm clear opening, the total weight shall not be less than 275 kg. In case of scraper manhole the frame

shall have clear opening of 1200 mm x 900 mm and shall weigh not less than 900 kg including cover. The manhole cover and frame shall be painted with three coats of anti-corrosive paint after fixing in position.

(b) Fibre Reinforced Concrete Frame and Cover

Fibre reinforced concrete frame and cover shall be capable of withstanding load of 35 tonnes. The frame shall be fixed in cement concrete of M15 grade all around and finished with neat cement. The fibre reinforced frame shall have clear opening of 560 mm diameter and weighing 102 kg. The cover shall have a minimum thickness of 100 mm and weighing 78 kg. The fibres shall constitute 1% of the weight of the concrete in the form of 50 mm to 100 mm long high tensile steel wires. For the cover, MS sheet lapping of 18 gauge shall be provided to avoid damage to the edges. Similarly for frame, MS angle/flat shall be provided along the edge. Both MS sheet and angle shall be painted with black bituminous paint. The cover should have suitable lifting arrangement. The fibre reinforced frame and cover shall be manufactured as approved.

(c) Reinforced Cement Concrete Frame and Cover

Reinforced cement concrete frame and cover for manholes shall be of required dimensions and shape as shown on the drawing prepared by the Contractor. The frame and cover shall be cast in cement concrete of M25 grade. Minimum cover to the reinforcement shall be 40 mm. The edges of frame and covers shall be provided with mild steel angles to avoid damages to the corners. These angles shall be painted with black bituminous paint. The covers should have suitable lifting arrangement.

7.15.12 Drop Manhole

When a sewer connects a main sewer, and where the difference in level between water line (peak flow levels) of main line and the invert level of branch lines is more than 600 mm or a drop of more than 600 mm is required to be given in the same sewer line and it is uneconomical or impractical to arrange the connection within 600 mm, a drop connection shall be provided for which a manhole shall be constructed as per relevant drawing, incorporating a vertical drop pipe from the higher sewer to the lower one. This pipe shall be provided outside the shaft and encased in concrete. A continuation of the branch sewer should be built through the shaft wall to form a rodding and inspection eye, which should be provided with a half blank flange. The diameter of the back drop should be at least as large as that of the incoming pipe. The drop pipe should terminate at its lower end with a plain or duck-foot bend turned so as to discharge its flow at 45 degrees or less to the direction of the flow in the main sewer. The pipe unless of cast iron should be surrounded with 150 mm thick concrete.

In the case of sewers over 450 mm in diameter the drop in level may be accomplished by one of the following approved methods:

(a) A cascade;
(b) A ramp;
(c) By drops in previous manholes.

7.15.13 RCC Manhole

M25 grade of concrete used for construction of RCC manhole shall have minimum cement content of 360 kg/cum of concrete. Minimum cover to the reinforcement shall be 50 mm.

7.15.14 Vent Shafts

(a) General

Vent shafts shall be erected at such places as approved by the Employer's Representative.

(b) Mild Steel Vent Shaft

Mild steel vent shaft shall be of 150 mm diameter and 12.17 m height from ground level with C.I. ornamental cap. This shall be fixed firmly and encased in cement concrete of M15 grade as shown on relevant drawing with necessary mild steel bolts, plates etc. for foundation. The vent shaft shall be painted with one coat of silver paint over one coat of red lead oxide paint. The vent shaft shall be connected to manhole by 150 mm diameter glazed stoneware pipe encased by M10 concrete of 150 mm thickness all around as approved by the Employer's Representative.

(c) RCC Vent Shaft

Reinforced cement concrete vent shaft shall be of M25 grade concrete, 200 mm diameter at bottom and tapered to 100 mm diameter at top (both inside clear openings) and 6 m height from ground level. The vent shaft shall be embedded in concrete of M10 grade and anchored by 2 nos. of 16 mm diameter and 600 mm long MS bars. The vent shaft shall be connected to manhole as specified in (b) above through a brick masonry flue chamber.

7.15.15 Miscellaneous

If any damage is caused to the other services such as water supply pipeline, sewer, cable, etc. during the construction of manholes and erection of vent shafts, the Contractor shall be held responsible for the same and shall replace the damaged services to the full satisfaction of the Employer's Representative.
The interior of manholes shall be cleared of all debris after construction and before testing the same for water tightness by the Contractor.

7.16 Measurement for Pipes

AC, Cast iron and S.W. drainage pipes shall be measured along the centrelines of pipes including all fittings such as junctions, plug bends etc., for which no separate payment shall be made.

GI pipes with fittings completely fixed in position shall be measured and paid for the finished centreline lengths, including all fittings such as tees, bends, couplings etc., for which no separate payment shall be made.

In measuring the lengths of sewer pipes laid, length between faces of manholes shall be considered. Inspection chambers shall only be measured omitting lengths of channels between inside faces of walls of manholes of chambers.

End of Section 7

SECTION 8

GENERAL CIVIL WORKS

SECTION 8

GENERAL CIVIL WORKS

8.1 Applicable Codes and Specifications

The following codes and standards are included in this section.

IS: 110	-	Ready mixed paint, brushing, grey filler, for enamels for use over primers
IS: 269	-	Specification for 33 grade ordinary Portland cement
IS: 278	-	Specification for Galvanized Steel Barbed wire and Fencing
IS: 280	-	Specification for mild steel wire for general engineering purposes
IS: 287	-	Recommendations for maximum permissible moisture content of timber used for different purposes
IS: 304	-	Specifications for High Tensile Brass Ingots and Castings.
IS: 337	-	Varnish, finishing interior
IS: 348	-	French polish
IS: 383	-	Specification for coarse and fine aggregates from natural sources for concrete
IS: 412	-	Specification for Expanded metal steel sheets for general purposes
IS: 419	-	Specification for putty for use on window frames
IS: 428	-	Distemper, oil emulsion, colour as required
IS: 459	-	Specification for unreinforced corrugated and semi-corrugated asbestos cement sheets
IS: 702	-	Specification for industrial bitumen
IS: 710	-	Specification for marine plywood
IS:712	-	Specification for building limes
IS:730	-	Specification for hook bolts for corrugated sheet roofing
IS:733	-	Specification for Wrought aluminium and aluminium alloys, bars, rods and sections for general engineering purposes
IS:777	-	Specification for glazed earthenware wall tiles
IS:1003	-	Specification for timber panelled and glazed shutters (Parts 1 & 2)
IS:1038	-	Specification for steel doors, windows and ventilators
IS: 1077	-	Specification for common burnt clay building bricks
IS: 1081	-	Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators
IS:1124	-	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones
IS:1237	-	Specification for cement concrete flooring tiles
IS:1322	-	Specification for Bitumen felts for water proofing and damp proofing

IS:1346	-	Code of practice for water proofing of roofs with bitumen felts
IS:1361	-	Specification for steel windows for industrial buildings
IS:1397	-	Specification for kraft paper
IS:1443	-	Code of practice for laying and finishing of cement concrete flooring tiles
IS:1477	-	Code of practice for painting of ferrous metals in buildings (Parts 1 & 2)
IS:1542	-	Specification for sand for plaster
IS:1580	-	Specification for bituminous compounds for water-proofing and caulking purposes
IS:1597	-	Code of practice for construction of stone masonry : Part 1 Rubble stone masonry
IS:1659	-	Specification for block boards
IS:1661	-	Code of practice for application of cement and cement-lime plaster finishes
IS:1834	-	Specification for hot applied sealing compound for joint in concrete
IS:1838	-	Specification for preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type) : Part 1 Bitumen impregnated fibre
IS:1948	-	Specification for aluminium doors, windows and ventilators
IS:1949	-	Specification for aluminium windows for industrial buildings
IS:2074	-	Ready mixed paint, air drying, red oxide- zinc chrome, priming
IS:2098	-	Specification for Asbestos cement building boards
IS:2114	-	Code of practice for laying in-situ terrazzo floor finish
IS:2116	-	Specification for sand for masonry mortars
IS:2185	-	Specification for concrete masonry units (Parts 1,2 & 3)
IS:2202	-	Specification for wooden flush door shutters (Solid core type) : Parts 1 & 2
IS:2212	-	Code of practice for brickwork
IS:2250	-	Code of practice for preparation and use of masonry mortars
IS:2338	-	Code of practice for finishing of wood and wood based materials (Parts 1 & 2)
IS:2339	-	Aluminium paint for general purposes, in dual container
IS:2395	-	Code of practice for painting concrete, masonry and plaster surfaces (Parts 1 & 2)
IS:2402	-	Code of practice for external rendered finishes
IS:2571	-	Code of practice for laying in-situ cement concrete flooring
IS:2572	-	Code of practice for construction of hollow concrete block masonry
IS:2645	-	Specification of integral cement waterproofing compounds
IS:2690	-	Specification for burnt clay flat terracing tiles : Part 1 Machine made
IS:2691	-	Specification for burnt clay facing bricks
IS:2721	-	Specification for Galvanized Steel Chain Link Fence Fabric
IS:2750	-	Specification for steel scaffoldings
IS:2835	-	Flat transparent sheet glass

IS:2932	-	Specification for enamel, synthetic, exterior type (a) undercoating, (b) finishing
IS:3007	-	Code of practice for laying of asbestos cement sheets - corrugated and (Part 1 & 2) semi-corrugated sheets
IS:3036	-	Code of practice for laying lime concrete for a water-proofed roof finish
IS:3067	-	Code of practice of general design details and preparatory work for damp-proofing and water- proofing of buildings
IS:3068	-	Specification for broken brick (burnt clay) coarse aggregates for use in lime concrete
IS:3384	-	Specification for bitumen primer for use in water-proofing and damp-proofing
IS:3461	-	Specification for PVC-asbestos floor tiles
IS:3462	-	Specification for unpacked flexible PVC flooring
IS:3495	-	Method of test for burnt clay building bricks: Part 1 to 4
IS:3536	-	Specification for ready mixed paint, brushing, wood primer, pink
IS:3564	-	Specification for door closers (hydraulically regulated)
IS: 3614 - (Part – 1)		Specification for fire checks doors : Part –I Plate metal covered and rolling type
IS: 3614 - (Part – 2)		Specification for metallic and non-metallic fire check doors : Part-2 Resistance test and performance criteria
IS:3696	-	Safety code of scaffolds and ladders (Parts 1 & 2)
IS:4020	-	Methods of test for wooden flush door : Type test
IS:4021	-	Specification for timber door, window and ventilator frames
IS:4351	-	Specification for steel door frames
IS:4443	-	Code of practice for use of resin type chemical resistant mortars
IS:4457	-	Specification for ceramic unglazed vitreous acid resisting tile
IS:4631	-	Code of practice for laying epoxy resin floor toppings
IS:4832	-	Specification for chemical resistant mortars (Part II)
IS:4860	-	Specification for acid resistant bricks
IS:4948	-	Specification for welded steel wire fabric for general use
IS:5318	-	Code of practice for laying of flexible PVC sheet and tile flooring
IS:5410	-	Cement paint, colour as required
IS:5411	-	Specification for plastic emulsion paint (Parts 1 & 2)
IS:5437	-	Figured rolled & wired glass
IS:5491	-	Code of practice for laying of in-situ granolithic concrete floor topping
IS:6041	-	Code of practice construction of autoclaved cellular concrete block masonry
IS:6042	-	Code of practice for construction of light weight concrete block masonry
IS:6248	-	Specification for metal rolling shutters and rolling grilles
IS:7193	-	Specification for glass fibre base coal tar pitch and bitumen felts

IS:7452	-	Specification for hot rolled steel sections for doors, windows and ventilators
IS:8042	-	Specification for white Portland cement
IS:8543	-	Methods of testing plastics
IS:8869	-	Specification for washers for corrugated sheet roofing
IS: 9197	-	Specification for epoxy resin, hardeners and epoxy resin composites for floor topping
IS:9862	-	Specification for ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, water and chlorine resisting
IS:12200	-	Code of practice for provision of waterstops at transverse contraction joints in masonry and concrete dams
BS: 476 (Part - 20)	-	Methods for determination of the fire resistance of elements of construction (General Principles)
BS: 476 (Part - 21)	-	Methods for determination of the fire resistance of load bearing elements of construction
BS:476 (Part - 22)	-	Methods for determination of the fire resistance of non-load bearing elements of construction
Part – IV	-	National Building code of India (Fire Protection)

8.2 Brickwork

8.2.1 Materials

Bricks used in the works shall conform to the requirements laid down in IS: 1077. The class of the bricks shall be as specifically indicated in the respective items of work.

The nominal size of the modular brick shall be 200mmx100mmx100mm with the permissible tolerances over the actual size of 190mmx90mmx90mm as per IS: 1077. The nominal thickness of one brick and half brick walls using modular bricks shall be considered as 200 mm and 100 mm respectively. In the event of use of traditional bricks of nominal size 230 mmx115mmx75mm with tolerance upto □3 mm in each dimension, one brick and half brick walls shall be considered as 230 mm and 115 mm respectively.

Bricks shall be sound, hard, homogenous in texture, well burnt in kiln without being vitrified, hand/machine moulded, deep red, cherry or copper coloured, of regular shape and size & shall have sharp and square edges with smooth rectangular faces. The bricks shall be free from pores, cracks, flaws and nodules of free lime. Hand moulded bricks shall be moulded with a frog and those made by extrusion process may not be provided with a frog. Bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 5N/sq.mm unless otherwise specified in the items of work.

The average water absorption shall not be more than 20 percent by weight upto class 12.5 and 15 percent by weight for higher classes. Bricks which do not conform to this requirement shall be rejected. Over or under burnt bricks are not acceptable for use in the works.

Sample bricks shall be submitted to the Engineer for approval and bricks supplied shall conform to approved samples. If demanded by Engineer, brick samples shall be got tested as per IS: 3495 by Contractor. Bricks rejected by Engineer shall be removed from the site of works within 24 hours.

Mortar for brick masonry shall consist of cement and sand and shall be prepared as per IS: 2250. Mix shall be in the proportion of 1:5 for brickwork of thickness one brick or above and 1:4 for brickwork of thickness half brick or below, unless otherwise specified in the respective items of work. Sand for masonry mortar shall conform to IS: 2116. The sand shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by Engineer. If so directed by the Engineer, sand shall be screened and washed till it satisfies the limits of deleterious materials.
For preparing cement mortar, the ingredients shall first be mixed thoroughly in dry condition. Water shall then be added and mixing continued to give a uniform mix of required consistency. Mixing shall be done thoroughly in a mechanical mixer, unless hand mixing is specifically permitted by the Engineer. The mortar thus mixed shall be used as soon as possible, preferably within 30 minutes from the time water is added to cement. Incase, the mortar has stiffened due to evaporation of water, this may be re-tempered by adding water as required to restore consistency, but this will be permitted only upto 30 minutes from the time of initial mixing of water to cement. Any mortar which is partially set shall be rejected and shall be removed forthwith from the site. Droppings of mortar shall not be reused under any circumstances.

The Contractor shall arrange for test on mortar samples if so directed by the Engineer.

8.2.2 Workmanship

Workmanship of brick work shall conform to IS: 2212. All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. The cement mortar for brick masonry work shall be as specified in the respective item of work. Brick work 200mm/230mm thick and over shall be laid in English Bond unless otherwise specified. 100mm/115mm thick brickwork shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be slightly pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Only full size bricks shall be used for the works and cut bricks utilised only to make up required wall length or for bonding. Bricks shall be laid with frogs uppermost.

All brickwork shall be plumb, square and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be levelled. The thickness of brick courses shall be kept uniform. In case of one brick thick or half brick thick wall, atleast one face should be kept smooth and plane, even if the other is slightly rough due to variation in size of bricks. For walls of thickness greater than one brick both faces shall be kept smooth and plane. All interconnected brickwork shall be carried out at nearly one level so that there is uniform distribution of pressure on the supporting structure and no portion of the work shall be left more than one course lower than the adjacent work. Where this is not possible, the work shall be raked back according to bond (and not saw toothed) at an angle not exceeding 45 deg. But in no case the level difference between adjoining walls shall exceed one metre. Brick work shall not be raised more than one metre per day.

Bricks shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 10mm/15mm by raking tools during the progress of work when the mortar is still green, so as to provide a proper key for the plastering/ pointing respectively to be done later. When plastering or pointing is not required to be done, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top.

During inclement weather conditions, newly built brick masonry works shall be protected by tarpaulin or other suitable covering to prevent mortar being washed away by rain.

Brickwork shall be kept constantly moist on all the faces for at least seven days after 24 hrs of laying. The arrangement for curing shall be got approved from the Engineer.

Double scaffolding having two sets of vertical supports shall be provided to facilitate execution of the masonry works. The scaffolding shall be designed adequately considering all the dead, live and possible impact loads to ensure safety of the workmen, in accordance with the requirements stipulated in IS:2750 and IS:3696 (Part I). Scaffolding shall be properly maintained during the entire period of construction. Single scaffolding shall not be used on important works and will be permitted only in certain cases as decided by the Engineer. Where single scaffolding is adopted, only minimum number of holes, by omitting a header shall be left in the masonry for supporting horizontal scaffolding poles. All holes in the masonry shall be carefully made good before plastering/pointing.

In the event of usage of traditional bricks of size 230 mm x115mm x75mm, the courses at the top of the plinth and sills as well as at the top of the wall just below the roof/floor slabs and at the top of the parapet shall be laid with bricks on edge.

All brickwork shall be built tightly against columns, floor slabs or other structural members.

To overcome the possibility of development of cracks in the brick masonry following measures shall be adopted.

For resting RCC slabs, the bearing surface of masonry wall shall be finished on top with 12 mm thick cement mortar 1:3 and provided with 2 layers of Kraft paper Grade 1 as per IS:1397 or 2 layers of 50 micron thick polyethylene sheets.

RCC/ steel beams resting on masonry wall shall be provided with reinforced concrete bed blocks of 50 mm thickness, projecting 50mm on either sides of the beam, duly finished on top with 2 layers of Kraft paper Grade 1 as per IS:1397 or 2 layers of 50 micron thick polyethylene sheets.

Steel wire fabric shall be provided at the junction of brick masonry and concrete before taking up plastering work.

Bricks for partition walls shall be stacked adjacent to the structural member to pre-deflect the structural member before the wall is taken up for execution. Further, the top most course of half or full brick walls abutting against either a de-shuttered slab or beam shall be built only after any proposed masonry wall above the structural member is executed to cater for the deflection of the structural element.

Reinforced cement concrete transoms and mullions of dimensions as indicated in the construction Drawings are generally required to be provided in the half brick partition walls.

Where the drawings indicate that structural steel sections are to be encased in brickwork, the brick masonry shall be built closely against the steel section, ensuring a minimum of 20 mm thick cement-sand mortar 1:4 over all the steel surfaces. Steel sections partly embedded in brickwork shall be provided with bituminous protective coating to the surfaces at the point of entry into the brick masonry.

Contractor shall note that the unit rates quoted for the masonry work shall be deemed to include for the installation of miscellaneous inserts such as pipe sleeves, bolts, steel sections with anchors etc. and provide pockets, leaving openings, cutting chases etc. in accordance with the construction drawings. Miscellaneous inserts shall be either supplied free by the Employer or to be furnished by the Contractor. Any of the miscellaneous inserts which are required to be fabricated and supplied by the Contractor and cement concrete to be provided in the pockets for holdfasts of door/window frames etc. shall however, be measured and paid for separately under the respective items of work.

Facing bricks of the type specified conforming to IS: 2691 shall be laid in the positions indicated on the drawings and all facing brickwork shall be well bonded to the backing bricks/RCC surfaces. The level of execution of the facing brick work shall at any time be lower by at least 600 mm below the level of the backing brickwork.

Facing bricks shall be laid over 10 mm thick backing of cement mortar. The mortar mix, thickness of joint and the type of pointing to be carried out shall be as specified in the item of works. The pattern of laying the bricks shall be as specifically indicated in the drawings.

For facing brickwork, double scaffolding shall be used.

Faced works shall be kept clean and free from damage, discoloration etc., at all times.

8.2.3 Measurement

Measurement shall be in cu. m correct to two places of decimal for brickwork of thickness one brick i.e. 200 mm/230 mm and above. Measurement shall be in sq. m correct to two places decimal for facing brickwork and brickwork of thickness half brick i.e. 100mm/115mm and below. Measurement shall be for the quantities as actually executed duly deducting for openings, lintels, transoms / mullions etc. All concrete works shall be measured and paid for separately under the respective items of work.

8.3 Uncoursed Random Rubble Masonry in Foundation, Plinth and Superstructure

8.3.1 Materials

Stones for the works shall be of the specified variety which is hard, durable, fine grained and uniform in colour (for superstructure work) free from veins, flaws and other defects. Quality and work shall conform to the requirements specified in IS:1597 (Part-I). The percentage of water absorption shall not exceed 5 percent as per test conducted in accordance with IS: 1124. The Contractor shall supply sample stones to the Engineer for approval. Stones shall be laid with its grains horizontal so that the load transmitted is always perpendicular to the natural bed.

Cement-sand mortar for stone masonry works shall be in the proportion of 1:6. Materials and preparation of mortar shall be as specified in clause 8.2.1.

8.3.2 Workmanship

For all works below ground level the masonry shall be random rubble uncoursed with ordinary quarry dressed stones for the hearting and selected quarry dressed stones for the facing.

For all works above ground level and in superstructure the masonry shall be random rubble uncoursed, well bonded, faced with hammer dressed stones with squared quoins at corners. The bushings on the face shall not be more than 40 mm on an exposed face and on the face to be plastered it shall not project by more than 12 mm nor shall it have depressions more than 10 mm from the average wall surface.

Face stones shall extend back sufficiently and bond well with the masonry. The depth of stone from the face of the wall inwards shall not be less than the height or breadth at the face. The length of the stone shall not exceed three times the height and the breadth on base shall not be greater than three-fourths the thickness of wall nor less than 150 mm. The height of stone may be up to a maximum of 300 mm. Face stones or hearting stones shall not be less than 150 mm in any direction.

Chips and spalls shall be used wherever necessary to avoid thick mortar joints and to ensure that no hollow spaces are left in the masonry. The use of chips and spalls in the hearting shall not exceed 20 percent of the quantity of stone masonry. Spalls and chips shall not be used on the face of the wall and below hearting stones to bring them to the level of face stones.

The maximum thickness of joints shall not exceed 20 mm. All joints shall be completely filled with mortar. When plastering or pointing is not required to be done, the joints shall be struck flush and finished as the work proceeds. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool during the progress of the work while the mortar is still green.

Through or bond stones shall be provided in walls up to 600 mm thick and in case of walls above 600 mm thickness, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous lime stone and sand stone, etc.) the bond stone shall extend about two-thirds into the wall and a set of two or more bond stones Overlapping each other by at least 150 mm shall be provided. Each bond stone or a set of bond stones shall be provided for every 0.5 sq. m of wall surface.

All stones shall be sufficiently wetted before laying to prevent absorption of water from the mortar. All connected walls in a structure shall be normally raised uniformly and regularly. However if any part of the masonry is required to be left behind, the wall shall be raked back (and not saw toothed) at an angle not exceeding 45deg. Masonry work shall not be raised by more than one metre per day.

Green work shall be protected from rain by suitable covering. Masonry work shall be kept constantly moist on all the faces for a minimum period of seven days for proper curing of the joints.

Type of scaffolding to be used shall be as specified in clause 8.2.2.

8.3.3 Measurement

Measurement shall be in cu. m correct to two places of decimal. The quantities measured and paid for, shall be those as actually executed after making necessary deductions for openings, lintels etc.

8.4 Coursed Rubble Masonry (First Sort) for Superstructure

8.4.1 Materials

The Material specification for the work shall be as per clause 8.3.1.

8.4.2 Workmanship

All courses shall be laid truly horizontal and shall be of the same height in any course. The height of course shall not be less than 150 mm and not more than 300 mm. The width of stone shall not be less than its height.

Face stones shall tail into the work for not less than their height and at least 1/3rd the number of stones shall tail into the work for a length not less than twice their height but not more than three-fourths the thickness of the wall whichever is smaller. These should be laid as headers and stretchers alternately to break joints by at least 75 mm.

The face stones shall be squared on all joints and beds; the bed joints being hammer or chisel dressed true and square for at least 80 mm back from the face and the side joints for at least 40 mm. The face of the stone shall be hammer dressed so that the bushing shall not be more than 40 mm on an exposed face and 10 mm on a face to be plastered. No portion of the dressed surface shall show a depth of gap more than 6 mm from a straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the surface of bed and side joints.

No spalls or pinnings shall be allowed on the face. All bed joints shall be horizontal and side joints shall be vertical and no joints shall be more than 10 mm in thickness. When plastering or pointing is not required to be done, the joints shall be struck flush and finished as the work proceeds. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool, during the progress of the work while the mortar is still green.

Hearting shall consist of flat bedded stones carefully laid on their proper beds and solidly bedded in mortar. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10 percent of the quantity of the stone masonry. Care shall be taken so that no hollow spaces are left anywhere in the masonry.

The requirement regarding through or bond stones shall be as specified in clause 8.3.2 with the further stipulation that these shall be provided at 1.5 m to 1.8m apart clear in every course but staggered at alternate courses.

The quoins which shall be of the same height as the course in which they occur, shall not be less than 450 mm in any direction. Quoin stones shall be laid as stretchers and headers alternately. They shall be laid square on their beds, which shall be rough chisel dressed to a depth of at least 100 mm from the face. These stones shall have minimum uniform chisel drafts of 25mm width at four edges, all the edges being in the same plane.

Type of scaffolding to be used shall be as per Clause 8.2.2.

Requirements of execution of the work and curing shall be as stipulated in clause 8.3.2 .

8.4.3 Measurement

Measurement shall be in cu. m correct to two places of decimal. The quantities measured and paid for, shall be those as actually executed after making necessary deductions for openings, lintels etc.

8.5 Concrete Block Masonry

8.5.1 Materials

Masonry units of hollow and solid concrete blocks shall conform to the requirements of IS : 2185 (Part 1).
Masonry units of hollow and solid light-weight concrete blocks shall conform to the requirements of IS : 2185 (Part 2).

Masonry units of autoclaved cellular concrete blocks shall conform to the requirements of IS:2185 (Part 3).

The height of the concrete masonry units shall not exceed either its length or six times its width.

The nominal dimensions of concrete block shall be as under.

Length 400, 500 or 600 mm
Height 100 or 200 mm
Width 100 to 300 mm in 50 mm increments

Half blocks shall be in lengths of 200, 250 or 300mm to correspond to the full length blocks. Actual dimensions shall be 10mm short of the nominal dimensions.

The maximum variation in the length of the units shall not be more than ±5 mm and maximum variation in height or width of the units shall not be more than ± 3mm.

Concrete blocks shall be either hollow blocks with open or closed cavities or solid blocks.

Concrete blocks shall be sound, free of cracks, chipping or other defects which impair the strength or performance of the construction. Surface texture shall as specified. The faces of the units shall be flat and rectangular, opposite faces shall be parallel and all arises shall be square. The bedding surfaces shall be at right angles to the faces of the block.

The concrete mix for the hollow and solid concrete blocks/light weight concrete blocks shall not be richer than one part of cement to six parts of combined aggregates by volume.

Concrete blocks shall be of approved manufacture, which satisfy the limitations in the values of water absorption, drying shrinkage and moisture movement, as specified for the type of block as per relevant IS code. Contractor shall furnish the test certificates and also supply the samples for the approval of Engineer.

8.5.2 Workmanship

The type of the concrete block, thickness and grade based on the compressive strength for use in load bearing and/or non-load bearing walls shall be as specified. The minimum nominal thickness of non-load bearing internal walls shall be 100mm. The minimum nominal thickness of external panel walls in framed construction shall be 200 mm.

The workmanship shall generally conform to the requirements of IS: 2572 for concrete block masonry, IS:6042 for light weight concrete block masonry and IS:6041 for autoclaved cellular concrete block masonry works.

From considerations of durability, generally concrete block masonry shall be used in superstructure works above the damp-proof course level.

Concrete blocks shall be embedded with a mortar which is relatively weaker than the mix of the blocks in order to avoid the formation of cracks. Cement mortar of proportion 1:6 shall be used for the works. Preparation of mortar shall be as specified in clause 8.2.1.

The thickness of both horizontal and vertical joints shall be 10mm. The first course shall be laid with greater care, ensuring that it is properly aligned, leveled and plumb since this will facilitate in laying succeeding courses to obtain a straight and truly vertical wall. For the horizontal (bedding) joint, mortar shall be spread over the entire top surface of the block including front and rear shells as well as the webs to a uniform layer of 10mm. For vertical joints, the mortar shall be applied on the vertical edges of the front and rear shells of the blocks. The mortar may be applied either to the unit already placed on the wall or on the edges of the succeeding unit when it is standing vertically and then placing it horizontally, well pressed against the previously laid unit to produce a compacted vertical joint. In case of two cell blocks with slight depression on the vertical sides these shall also be filled up with mortar to secure greater lateral rigidity. To assure satisfactory bond, mortar shall not be spread too far ahead of actual laying of the block as the mortar will stiffen and lose its plasticity Mortar while hardening

shrinks slightly and thus pulls away from the edges of the block. The mortar shall be pressed against the units with a jointing tool after it has stiffened to effect intimate contact between the mortar and the unit to obtain a weather tight joint. The mortar shall be raked to a depth of 10mm as each course is laid to ensure good bond for the plaster.

Dimensional stability of hollow concrete blocks is greatly affected by variations of moisture content in the units. Only well dried blocks should be used for the construction. Blocks with moisture content more than 25% of maximum water absorption permissible shall not be used. The blocks should not be wetted before or during laying in the walls. Blocks should be laid dry except slightly moistening their surfaces on which mortar is to be applied to obviate absorption of water from the mortar.

As per the design requirements and to effectively control cracks in the masonry, RCC bound beams/studs, joint reinforcement shall be provided at suitable locations. Joint reinforcement shall be fabricated either from mild steel wires conforming to IS:280 or welded wire fabric/high strength deformed basis as per the drawings.

For jambs of doors, windows and openings, solid concrete blocks shall be provided. If hollow units are used, the hollows shall be filled with concrete of mix 1:3:6. Hold fasts of doors/windows should be arranged so that they occur at block course level.

At intersection of walls, the courses shall laid up at the same time with a true masonry bond between atleast 50% of the concrete blocks. The sequence for construction of partition walls and treatment at the top of load bearing walls for the RCC slab shall be as detailed under clause 8.2 for the brick work.

Curing of the mortar joints shall be carried out for atleast 7 days. The walls should only be lightly moistened and shall not be allowed to become excessively wet.

Double scaffolding as per clause 8.2.2 shall be adopted for execution of block masonry work.

Cutting of the units shall be restricted to a minimum. All horizontal and vertical dimensions shall be in respectively, adopting modular co-ordination for walls, opening locations for doors, windows etc.

Concrete blocks shall be stored at site suitably to avoid any contact with moisture from the ground and covered to protect against wetting.

8.5.3 Measurement

Measurement shall be in cu. m. correct up to two places of decimal for walls of thickness 200 mm and above. Measurement shall be in sq.m correct upto two places of decimal for walls of 100 mm/150 mm in thickness. Measurement shall be for the quantities as actually executed duly deducting for openings and concrete works. Concrete and reinforcement will be measured and paid for separately. The rate quoted shall be for the type of masonry blocks specified in the respective items of work which shall include for the specific sequential operations as stipulated in the construction drawings.

8.6 Damp - Proof Course

8.6.1 Materials and Workmanship

Where specified, all the walls in a building shall be provided with damp-proof course cover plinth to prevent water from rising up the wall. The damp-proof course shall run without a break throughout the length of the wall, even under the door or other openings. Damp-proof course shall consist of 75 mm thick cement concrete of 1:2:4 nominal mix with approved water-proofing compound admixture conforming to IS: 2645 in proportion as directed by the manufacturer. Concrete shall be with 10 mm down graded coarse aggregates.

The surface of brick work/stone masonry work shall be leveled and prepared before laying the cement concrete. Side shuttering shall be properly fixed to ensure that slurry does not leak through and is also not disturbed during compaction. The upper and side surface shall be made rough to afford key to the masonry above and to the plaster.

Damp-proof course shall be cured properly for atleast seven days after which it shall be allowed to dry for taking up further work.

8.6.2 Measurement

Measurement of damp-proof course shall be in sq.m correct to two places of decimal as actually executed. No separate payment will be made for formwork.

8.7 Miscellaneous Inserts, Bolts etc.

All the miscellaneous inserts such as bolts, pipes, plate embedment etc., shall be accurately installed in the building works at the correct location and levels, all as detailed in the construction drawings. Contractor shall prepare and use templates for this purpose, if so directed by the Engineer. In the event, of any of the inserts are improperly installed, Contractor shall make necessary arrangements to remove and reinstall at the correct locations/levels, all as directed by the Engineer without any extra cost to the Employer.

8.7 .1 Measurement

Miscellaneous inserts, supplied by the Contractor shall be measured and paid for as per the respective items of work.

8.8 Wood Work in Doors, Windows, Ventilators & Partitions

8.8.1 Materials

Timber to be used shall be first class Teak wood as per IS:4021. Timber shall be of the best quality and well seasoned by a suitable process before being planed to the required sizes. The maximum permissible moisture content shall be from 10 to 16 percent for timber 50mm and above in thickness and 8 to 14 percent of timber less than 50mm in thickness for different regions of the country as stipulated in IS:287. Timber shall be close grained, of uniform colour and free from decay, fungal growth, boxed heart, pitch pockets or streaks on the exposed edges, borer holes, splits and cracks.

Flush door shutters of the solid core type with plywood face panels shall conform to IS: 2202 (Part 1) and with particle board/hard board face panels shall conform to IS: 2202 (Part 2).

Transparent sheet glass shall conform to the requirements of IS: 2835. Wired and figured glass shall be as per IS: 5437.

Builder's hardware for fittings and fixtures shall be of the best quality from approved manufacturers.

8.8.2 Workmanship

The workmanship and finish of wood work in doors, windows, ventilators and partitions shall be of a very high order. Contractor shall ensure that work is executed in a professional manner by skilled carpenters for good appearance, efficient and smooth operation of the shutters.

All works shall be executed as per the detailed drawings and/or as directed by the Engineer.

All members of the door, window, and ventilator shall be straight without any warp or bow and shall have smooth well planed faces. The right angle shall be checked from the inside surfaces of the

respective members of the frame. Frames shall have mortice and tenon joints which shall be treated with an approved adhesive and provided with metal or wood pins. The vertical members of the door frame shall project 50 mm below the finished floor level. The finished dimension of frames shall be rebated on the solid for keying with the plaster and for receiving the shutters. The depth of rebate for housing the shutter shall be 15 mm. The size of the frames shall be as specified in the respective items of work. The workmanship shall generally conform to the requirements specified in IS:4021. The face of the frames abutting the masonry or concrete shall be provided with a coat of coal tar.

Three hold fasts using 25 mm x 6 mm mild steel flats 225 mm long with split ends shall be fixed on each side of door and window frames, one at the centre and the other two at 300 mm from the top and bottom of the frame. For window and ventilator frames less than 1 m in height, two hold fasts on each side shall be fixed at quarter points.

Timber panelled shutters for doors, windows and ventilators shall be constructed in the form of framework of stiles and rails with panel insertion. The panels shall be fixed by either providing grooves in the stiles and rails or by beading. Glazing bars shall be as detailed in the drawings. The stiles and rails shall be joined by mortice and tenon joints at right angles. All members of the shutter shall be straight without any warp or bow and shall have smooth, well planed faces at right angles to each other. The right angle for the shutter shall be checked by measuring the diagonals and the difference shall not be more than 3 mm. Timber panels made from more than one piece shall be jointed with a continuous tongued and grooved joint, glued together and reinforced with metal dowels. The workmanship shall generally conform to the requirements specified in IS: 1003 (Parts 1 & 2). The thickness of the shutter, width/thickness of the stiles/rails/panel type shall be as specified. Marine plywood panels conforming to IS: 710 shall be used for doors where specified.

Details of the wooden flush door shutters, solid core type with specific requirement of the thickness, core, face panels, viewing glazed panel, venetian louvre opening, teak wood lipping etc. shall be as pecified. Panels of shutter shall be of marine plywood conforming to IS: 710. Flush door shutters shall be from reputed manufacturers and Contractor shall submit test results as per IS: 4020, if so desired by the Engineer.

Glazing of door, window, ventilator and partitions shall be with either flat transparent sheet glass, wired or figured glass. Transparent sheet glass shall be of 'B' quality as per IS: 2835.The thickness and type of glazing to be provided shall be as specified in the item of work.

The material of the fittings and fixtures either of chromium plated steel, cast brass, copper oxidised or anodised aluminium shall be as specified. The number, size and type of the fittings and fixtures shall be as indicated in the drawings/item of work.

Wood work shall not be provided with the finishes of painting/varnishing etc. unless it has been approved by the Engineer. The type of finish and the number of coats shall be as stipulated in the respective items of work.

Wooden hand railing and architraves shall be of the size and shape with the fixing arrangement as indicated in the drawings.

The framework of the partitions with mullions and transomes shall be with the sections of dimensions as specified. Panels of double/single glazing/plywood shall be fixed as per details specified. Partitions shall be fixed rigidly between the floor and structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels, at locations as per the Construction drawings.

Any carpentry work which shows defects due to inadequate seasoning of the timber or bad workmanship shall be removed and replaced by Contractor with work as per Specifications at no extra cost to the Employer.

8.8.3 Measurement

Measurement for doors, windows, ventilators, architraves and partitions shall be in sq.m correct to two places of decimal. Handrailing shall be measured in running metres correct to two places of decimal. Measurement shall be from out to out of the frames. Rates quoted shall be for all the works including glazing, painting, Builder's hardware of fittings and fixtures as specifically described in the respective items of work.

8.9 Steel Doors, Windows and Ventilators

8.9.1 Materials

Hot rolled steel sections for the fabrication of steel doors, windows and ventilators shall conform to IS: 7452 which are suitable for single glazing .

Pressed steel door frames for steel flush doors shall be out of 1.25mm thick mild steel sheets of profiles as per IS : 4351.

Transparent sheet glass shall conform to the requirements of IS : 2835. Wired and figured glass shall be as per IS: 5437.

Builder's hardware of fittings and fixtures shall be of the best quality from the approved manufacturers.

8.9.2 Workmanship

All steel doors, windows and ventilators shall be of the type as specified in the respective items of work and of sizes as indicated in the drawings. Steel doors, windows and ventilators shall conform to the requirements as stipulated in IS : 1038. Steel windows shall conform to IS : 1361, if so specified.

Doors, windows and ventilators shall be of an approved manufacture. Fabrication of the unit shall be with rolled section, cut to correct lengths and mitred. Corners shall be welded to form a solid fused welded joint conforming to the requirements of IS : 1038. Tolerance in overall dimensions shall be within ±1.5mm. The frames and shutters shall be free from wrap or buckle and shall be square and truly plain. All welds shall be dressed flush on exposed and contact surfaces. Punching of holes, slots and other provisions to install fittings and fixtures later shall be made at the correct locations as per the requirements. Samples of the units shall be got approved by the Engineer before further manufacture/purchase by the Contractor.

Type and details of shutters, hinges, glazing bar requirement, couplings, locking arrangement, fittings and fixtures shall be as described in the respective items of work and / or as shown in the drawings for single or composite units.

For windows with fly proof mesh as per the item of work, rotor operator arrangement, for the operation of the glazed shutters from the inside shall be provided.

Pressed steel door frames shall be provided with fixing lugs at each jamb, hinges, lock-strike plate, mortar guards, angle threshold, shock-absorbers of rubber or similar material as per the requirements of IS : 4351. Pressed steel door frames shall be fixed as `built-in' as the masonry work proceeds. After placing it plumb at the specified location, masonry walls shall be built up solid on either side and each course grouted with mortar to ensure solid contact with the door frame, without leaving any voids. Temporary struts across the width shall be fixed, during erection to prevent bow/sag of the frame.

Door shutters of flush welded construction shall be 45mm thick, fabricated with two outer skins of 1.25mm thick steel sheets, 1mm thick steel sheet stiffeners and steel channels on all four edges.

Double shutters shall have meeting stile edge bevelled or rebated. Provision of glazed viewing panel, louvers shall be made as per the items of works and/or drawings. Shutters shall be suitably reinforced for lock and other surface hardware and to prevent sagging/twisting. Single sheet steel door shutters shall be fabricated out of 1.25mm thick steel sheets, mild steel angles and stiffeners as per the drawings.

Doors, windows and ventilators shall be fixed into the prepared openings. They shall not be 'built-in' as the masonry work proceeds, to avoid distortion and damage of the units. The dimensions of the masonry opening shall have 10mm clearance all-round the overall dimensions of the frame for this purpose. Any support of scaffolding members on the frames/glazing bars is prohibited.

Glazing of the units shall be either with flat transparent glass or wired / figured glass of the thickness as specified in the items of works. All glass panels shall have properly squared corner and straight edges. Glazing shall be provided on the outside of the frames.

Fixing of the glazing shall be either with spring glazing clips and putty conforming to IS:419 or with metal beads. Pre-formed PVC or rubber gaskets shall be provided for fixing the beads with the concealed screws. The type of fixing the glazing shall be as indicated in the items of work and/or in drawings.

Steel doors, windows and ventilators shall be provided with finish of either painting as specified or shall be hot dip galvanised with thickness of the zinc coating as stipulated all as described in the respective items of works.

The material of the Builders hardware of fittings and fixtures of chromium plated steel, cast brass, brass copper oxidised or anodised aluminium shall be as specified in the items of works. The number, size and type of fittings and fixtures shall be as in the Drawings /items of work.

Installation of the units with fixing lugs, screws, mastic caulking compound at the specified locations shall generally conform to the requirements of IS:1081. Necessary holes etc required for fixing shall be made by the Contractor and made good after installation. Workmanship expected is of a high order for efficient and smooth operation of the units.

8.9.3 Measurement

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be from out to out of the frames. Rates quoted shall be for the works including glazing, painting, Builder's hardware of fittings and fixtures as specifically described in the respective items of work.

8.10 Aluminium Doors, Windows, Ventilators & Partitions

8.10.1 Materials

Aluminum alloy used in the manufacture of extruded sections for the fabrication of doors, windows, ventilators shall conform to designation HE9-WP of IS:733.

Transparent sheet glass shall conform to the requirements of IS:2835. Wired and figured glass shall be as per IS:5437.

Builder's hardware of fittings & fixtures shall be of the best quality from approved manufacturers.

8.10.2 Workmanship

All aluminum doors, windows, ventilators and partitions shall be of the type and size as specified. The doors, windows, ventilators shall conform to the requirements of IS:1948. Aluminum windows, shall conform to IS:1949, if so specified.

All aluminum units shall be supplied with anodized finish. The minimum anodic film thickness shall be 0.015 mm.

Doors, windows and ventilators shall be of an approved manufacture. Fabrication of the units shall be with the extruded sections, cut to correct lengths, mitred and welded at the corners to a true right angle conforming to the requirements of IS:1948. Tolerance in overall dimensions shall be within ± 1.5mm. The frames and shutters shall be free from warp or buckle and shall be square and truly plane. Punching of holes, slots and other provisions to install fittings or fixtures later shall be made at the correct locations, as per the requirements.

Aluminium swing type doors, aluminum sliding windows, partitions shall be as described in the items of work / drawings.

IS:1948 and IS:1949 refers to incorporating the sizes, shapes, thicknesses and weight per running metre of extruded sections for various components of the units. However, new sizes, shapes, thicknesses with modifications to suit snap-fit glazing clips etc. are continuously being added by various leading manufacturers of extruded sections, which are available in the market. As such, the sections of the various components of the unit proposed by the Contractor, will be reviewed by the Engineer and will be accepted only if they are equal to or marginally more than that given in the codes / specified in the items of work.

The framework of the partitions with mullions and transomes shall be with anodised aluminium box sections. Anodised aluminium box sections shall be in-filled with timber of class 3 (silver oak or any other equivalent) as per IS:4021. Panels of double/single glazing/plywood shall be fixed as per details indicated in the drawings. Partitions shall be fixed rigidly between the floor and the structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels, at locations as per the construction drawings.

Specific provisions as stipulated for steel doors, windows, ventilators under clause 8.9.2 shall also be applicable for this item work. Glazing beads shall be of the snap-fit type suitable for the thickness of glazing proposed as indicated in the items of works. A layer of clear transparent lacquer shall be applied on aluminium sections to protect them from damage during installation. This lacquer coating shall be removed after the installation is completed.

8.10.3 Measurement

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be from out of the frames. Rate quoted shall be for the works including glazing, Builder's hardware of fittings and fixtures as specifically described in the respective items of work.

8.11 Steel Rolling Shutters

8.11.1 Materials and Workmanship

Rolling shutters shall be of an approved manufacture, conforming to the requirements specified in IS: 6248.

The type of rolling shutter shall be self coiling type (manual) for clear areas upto 12 sq.m, gear operated type (mechanical) for clear areas upto 35 sq.m and electrically operated type for areas upto 50 sq.m. Mechanical type of rolling shutters shall be suitable for operation from both inside and outside with the crank handle or chain gear operating mechanism duly considering the size of wall/column. Electrical type of rolling shutter shall also be provided with a facility for emergency mechanical operation.

Rolling shutters shall be supplied duly considering the type, specified clear width/height of the opening and the location of fixing as indicated in the drawings.

Shutters shall be built up of interlocking laths 75 mm width between rolling centres formed from cold rolled steel strips. The thickness of the steel strip shall not be less than 0.90 mm for shutters upto 3.50m width and not less than 1.20 mm for shutters above 3.50 m width. Each lath section shall be continuous single piece without any welded joint.

The guide channels out of mild steel sheets of thickness not less than 3.15 mm shall be of either rolled, pressed or built up construction. The channel shall be of size as stipulated in IS:6248 for various clear widths of the shutters.

Hood covers shall be of mild steel sheets not less than 0.90 mm thick and of approved shape.

Rolling shutters shall be provided with a central hasp and staple safety device in addition to one pair of lever locks and sliding locks at the ends.

All component parts of the steel rolling shutter (excepting springs and insides of guide channels) shall be provided with one coat of zinc chrome primer conformity to IS:2074 at the shop before supply. These surfaces shall be given an additional coat of primer after erection at the site along with the number of coats and type of finish paint as specified in the respective items of work.

In case of galvanised rolling shutter, the lath sections, guides, lock plate, bracket plates, suspension shaft and the hood cover shall be hot dip galvanised with a zinc coating containing not less than 97.5 percent pure zinc. The weight of the zinc coating per sq.m shall be as specified in the items of work.

Guide channels shall be installed truly plumb at the specified location. Bracket plate shall be rigidly fixed with necessary bolts and holdfasts. Workmanship of erection shall ensure strength and rigidity of rolling shutter for trouble free and smooth operation.

8.11.2 Measurement

Measurement shall be in sq.m correct to two places of decimal of the clear area of the opening. Quoted rate shall be inclusive of painting as specified in the item of work.

8.12 Rubble Sub-Base

8.12.1 Materials

Stones used for rubble packing under floors on grade, foundations etc., shall be clean, hard, durable rock free from veins, flaws, laminations, weathering and other defects. Stones shall generally conform to the requirements stipulated in IS: 1597 (Part I).

Stones shall be as regular as can be obtained from quarries. Stones shall be of height equal to the thickness of the packing proposed with a tolerance of 10 mm. Stones shall not have a base area neither less than 250 sq cm nor more than 500 sq.cm, and the smallest dimension of any stone shall not be less than half the largest dimension. The quality and size of stones shall be subject to the approval of the Engineer.

8.12.2 Workmanship

Stones shall be hand packed carefully and laid with their largest base downwards resting flat on the prepared sub-grade and with their height equal to the thickness of the packing. Stones shall be laid breaking joints and in close contact with each other. All interstices between the stones shall be wedged-in by small stones of suitable size, well driven in by crow bars and hammers to ensure tight packing and complete filling-in of the interstices. The wedging shall be carried out simultaneously

with the placing in position of rubble packing and shall not lag behind. After this, any interstices between the smaller wedged stones shall be infilled with clean hard sand by brooming so as to fill the joints completely.

The laid rubble packing shall be sprinkled with water and compacted by using suitable rammers.

8.12.3 Measurement

Measurement shall be in sq.m correct to two places of decimal for the specified compacted thickness of rubble sub-base.

8.13 Base Concrete

The thickness and grade of concrete and reinforcement shall be as specified in items of work.

Before placing the blinding concrete, the sub-base of rubble packing shall be properly wetted and rammed. Concrete for the base shall then be deposited between the forms, thoroughly tamped and the surface finished level with the top edges of the forms. Two or three hours after the concrete has been laid in position, the surface shall be roughened using steel wire brush to remove any scum or laitance and swept clean so that the coarse aggregates are exposed. The surface of the base concrete shall be left rough to provide adequate bond for the floor finish to be provided later.

8.13.1 Measurement

Measurement shall be in sq.m correct to two places of decimal. This work could be either separate or combined along with the floor finish as indicated in the respective items of work

8.14 Terrazzo and Plain Cement Tiling Work

8.14.1 Materials

Terrazzo tiles and cement tiles shall generally conform in all respects to standards stipulated in IS: 1237. Tiles shall be of the best quality manufactured adopting hydraulic pressure of not less than $14N/mm^2$.

The type, quality, size, thickness colour etc, of the tiles for flooring/dado/skirting shall be as specified in the items of work.

The aggregates for terrazzo topping shall consist of marble chips which are hard, sound and dense. Cement to be used shall be either ordinary Portland cement or white cement with or without colouring pigment. The binder mix shall be with 3 parts of cement to 1 part of marble powder by weight. The proportion of cement shall be inclusive of any pigments. For every one part of cement-marble powder binder mix, the proportion of aggregates shall be 1.75 parts by volume, if the chips are between 1mm to 6mm and 1.50 parts by volume if the chips are between 6mm to 25mm.

The minimum thickness of wearing layer of terrazzo tiles shall be 5mm for tiles with chips of size varying from 1mm upto 6mm or from 1mm upto 12mm. This shall be 6mm for tiles with chips varying from 1mm upto 25mm. The minimum thickness of wearing layer of cement/coloured cement tiles shall be 5mm. This shall be 6mm for heavy duty tiles. Pigment used in the wearing layer shall not exceed 10 percent of the weight of cement used in the mix.

8.14.2 Workmanship

Laying and finishing of tiles shall conform to the requirements of workmanship stipulated in IS:1443.

Tiling work shall be commenced only after the door and window frames are fixed and plastering of the walls/ ceiling is completed. Wall plastering shall not be carried out upto about 50mm above the level of proposed skirting/dado.
The base concrete shall be finished to a reasonably plane surface about 40 to 45mm below the level of finished floor. Before the tiling work is taken up, the base concrete or structural slab shall be cleaned of all loose materials, mortar droppings, dirt, laitance etc. using steel wire brush and well wetted without allowing any water pools on the surface.

A layer of 25mm average thickness of cement mortar consisting of one part of cement to 6 parts of sand shall be provided as bedding for the tiles over the base concrete. The thickness of bedding mortar shall not be less than 10mm at any place. The quantity of water to be added for the mortar shall be just adequate to obtain the workability for laying. Sand for the mortar shall conform to IS:2116 and shall have minimum fineness modulus of 1.5. The surface shall be left rough to provide a good bond for the tiles. The bedding shall be allowed to harden for a day before laying of the tiles.

Neat cement slurry using 4.4 kg of cement per sq.m of floor area shall be spread over the hardened mortar bedding over such an area at a time as would accommodate about 20 tiles. Tiles shall be fixed in this slurry one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be in straight lines and shall normally be 1.5mm wide. On completion of laying of the tiles in a room, all the joints shall be cleaned and washed fairly deep with a stiff broom/wire brush to a minimum depth of 5mm. The day after the tiles have been laid, the joints shall be filled with cement grout of the same shade as the colour of the matrix of the tile. For this purpose white cement or grey cement with or without pigments shall be used. The flooring should be kept moist and left undisturbed for 7 days for the bedding/joints to set properly. Heavy traffic shall not be allowed on the floor for atleast 14 days after fixing of the tiles.

About a week after laying the tiles, each and every tile shall be lightly tapped with a small wooden mallet to find out if it gives a hollow sound; if it does, such tiles along with any other cracked or broken tiles shall be removed and replaced with new tiles to proper line and level. The same procedure shall be followed again after grinding the tiles and all damaged tiles replaced, properly jointed and finished to match. For the purpose of ensuring that such replaced tiles match with those laid earlier, it is necessary that the Contractor shall procure sufficient quantity of extra tiles to meet this contingency.

Wherever a full tile cannot be provided, tiles shall be cut to size and fixed. Floor tiles adjoining the wall shall go about 10mm under the plaster, skirting or dado.

Tile skirting and dado work shall be executed only after laying tiles on the floor. For dado and skirting work, the vertical wall surface shall be thoroughly cleaned and wetted. Thereafter it shall be evenly and uniformly covered with 10mm thick backing of 1:4 cement sand mortar. For this work the tiles as obtained from the factory shall be of the size required and practically full polished. The back of each tile to be fixed shall be covered with a thin layer of neat cement paste and the tile shall then be gently tapped against the wall with a wooden mallet. Fixing shall be done from the bottom of the wall upwards. The joints shall be in straight lines and shall normally be 1.5mm wide. Any difference in the thickness of the tiles shall be evened out in the backing mortar or cement paste so that the tile faces are in conformity & truly plumb. Tiles for use at the corners shall be suitably cut with bevelled edges to obtain a neat and true joint. After the work has set, hand polishing with carborundum stones shall be done so that the surface matches with the floor finish. Contractor shall note that the unit rate quoted for skirting shall also include for any chipping of the brickwork required to be carried out for this item.

Wall plastering of the strip left out above the level of skirting/dado shall be taken up after the tiles are fixed.

Chequered terrazzo tiles for flooring and for stair treads shall be delivered to site after the first machine grinding.

Machine grinding and polishing shall be commenced only after a lapse of 14 days of laying. The sequence and three numbers of machine grinding operations, usage of the type of carborundum stones, filling up of pin holes, watering etc. shall be carried out all as specified in IS:1443.

Tiles shall be laid to the levels specified. Where large areas are to be tiled the level of the central portion shall be kept 10mm higher than that at the walls to overcome optical illusion of a depression in the central portion. Localized deviation of ±3mm in any 3m length is acceptable in a nominally flat floor.

8.14.3 Measurement

Measurement for floor tiling and dado shall be in sq. m correct to two places of decimal. Actual quantity of tiling work as laid shall be measured for payment as per the respective items of work after making deductions for openings etc. Measurement for skirting shall be in running metres correct to two places of decimal for the specified height as per the item of work.

8.15 In-Situ Terrazzo Work

8.15.1 Materials

The requirements of marble aggregates for terrazzo topping shall be as per clause 8.14.1.

Cement shall first be mixed with the marble powder in dry state. The mix thus obtained shall be mixed with the aggregates in the specified proportions. Care shall be taken not to get the materials into a heap which results in the coarsest chips falling to the edges and cement working to the centre at the bottom. Materials shall be kept, as far as possible, in an even layer during mixing. After the materials have been thoroughly mixed in the dry state, water shall be added, just adequate to obtain plastic consistency for the desired workability for laying. The mix shall be used in the works within 30 minutes of the addition of water to the cement.

8.15.2 Workmanship

The thickness, type, quality, size and colour of chips etc. for the in-situ terrazzo finish for flooring/dado/ skirting shall be as specified in the respective items of works. Laying and finishing of in-situ work shall conform to the requirements of workmanship stipulated in IS: 2114.

In-situ terrazzo finish shall be laid over hardened concrete base. The finish layer consists of an under layer and terrazzo topping. The underlayer shall be of cement concrete of mix 1:2:4 using 10mm down graded coarse aggregates. The combined thickness of under layer and topping shall not be less than 30 mm for flooring and 20mm for dado/skirting work.

The minimum thickness of topping shall be 6mm if chips used are between 1mm to 4mm, 9mm if chips are between 4mm to 7mm and 12mm if chips are between 7mm to 10mm. If chips larger than 10mm size are used, the minimum thickness shall be one and one third the maximum size of chips.

Both the underlayer and later the topping shall be divided into panels not exceeding 2 sq.m for laying so as to reduce the possibility of development of cracks. The longer dimension of any panel shall not exceed 2m. Dividing strips shall be used to separate the panels. When the dividing strips are not provided, the bays shall be laid alternately, allowing an interval of atleast 24 hours between laying adjacent bays.

Dividing strips shall be either of aluminium, brass or other material as indicated in the items of works. Aluminum strips should have a protective coating of bitumen. The thickness of the strips shall be not less than 1.5mm and width not less than 25mm for flooring work.

Concrete base shall be finished to a reasonably plane surface to a level below the finished floor elevation equal to the specified thickness of terrazzo finish. Before spreading the underlayer, the base concrete surface shall be cleaned of all loose materials, mortar droppings, dirt, laitance etc. and well wetted without allowing any water pools on the surface. Dividing strips or screed strips, if dividing strips are not provided shall be fixed on the base and levelled to the correct height to suit the thickness of the finish. Just before spreading the underlayer the surface shall be smeared with cement slurry at 2.75 Kg/sq.m. Over this slurry, the underlayer shall be spread and levelled with a screening board. The top surface shall be left rough to provide a good bond for the terrazzo topping.

Terrazzo topping shall be laid while the underlayer is still plastic and normally between 18 to 24 hours after the underlayer is laid. Cement slurry of the same colour as the topping shall be brushed on the surface immediately before laying is commenced. The terrazzo mix shall be laid to a uniform thickness and compacted thoroughly by tamping and with a minimum of troweling. Straight edge and steel floats shall be used to bring the surface true to the required level in such a manner that the maximum amount of marble chips come up and spread uniformly all over the surface.

The surface shall be left dry for air-curing for a period of 12 to 18 hours. Thereafter it shall be cured by allowing water to stand in pools for a period of not less than 4 days.

Machine grinding and polishing shall be commenced only after a lapse of 7 days from the time of completion of laying. The sequence and four numbers of machine grinding operations, usage of the type of carborundum stones, filling up of pinholes, wet curing, watering etc shall be carried out all as specified in IS: 2114.

8.15.3 Measurement

Measurement shall be as per clause 8.14.3.

8.16 Shahabad / Tandur/ Kota Stone Slab work

8.16.1 Materials

The slabs shall be of approved selected quality, hard, sound, dense and homogenous in texture, free from cracks, decay, weathering and flaws. The percentage of water absorption shall not exceed 5 percent as per test conducted in accordance with IS : 1124.

The slabs shall be hand or machine cut to the required thickness. Tolerance in thickness for dimensions of tile more than 100mm shall be ±5mm. This shall be ±2mm on dimensions less than 100mm.

Slabs shall be supplied to the specified size with machine cut edges or fine chisel dressed to the full depth. All angles and edges of the slabs shall be true and square, free from any chipping giving a plane surface. Slabs shall have the top surface machine polished (first grinding) before being brought to site. The slabs shall be washed clean before laying.

8.16.2 Workmanship

The type, size, thickness and colour/shade etc. of the slabs for flooring/dado/skirting shall be as specified in the respective items of work.

Preparation of the concrete base, laying and curing shall be as per clause 8.14.2.

Dado / skirting work shall be as per clause 8.14.2. The thickness of the slabs for dado/skirting work shall not be more than 25mm. Slabs shall be so placed that the back surface is at a distance of 12mm. If necessary, slabs shall be held in position temporarily by suitable method. After checking for

verticality, the gap shall be filled and packed with cement sand mortar of proportion 1:3. After the mortar has acquired sufficient strength, the temporary arrangement holding the slab shall be removed.

Grinding and polishing shall be as per clause 8.14.2 except that first grinding with coarse grade carborundum shall not be done and cement slurry with or without pigment shall not be applied before polishing.

8.16.3 Measurement

Measurement shall be as per clause 8.14.3.

8.17 Carborundum Tile Finish

8.17.1 Materials

Carborundum tiles shall generally conform in all respects to the standards stipulated in IS:1237 for heavy duty tiles. Tiles shall be of the best quality manufactured adopting hydraulic pressure of not less than 14 N/mm^2.

The topping shall be uniform and of thickness not less than 6mm. The quantity of carborundum grit shall be not less than 1.35 kg/sq.m used with cement with or without pigment. The carborundum grit shall pass through 1.18mm mesh and shall be retained on 0.60 mm mesh.

The size, thickness, colour and plain or chequered etc of the tiles for flooring / skirting shall be as specified in the respective items of work.

8.17.2 Workmanship

Requirements as detailed for terrazzo/cement tile finish under clause 8.14.2 shall be applicable for carborundum tile flooring.

8.17.3 Measurement

Measurement shall be as per clause 8.14.3.

8.18 Glazed Tile Finish

8.18.1 Materials

Glazed earthenware tiles shall conform to the requirements of IS: 777. Tiles shall be of the best quality from an approved manufacturer. The tiles shall be flat, true to shape and free from flaws such as crazing, blisters, pinholes, specks or welts. Edges and underside of the tiles shall be free from glaze and shall have ribs or indentations for a better anchorage with the bedding mortar. Dimensional tolerances shall be as specified in IS: 777.

8.18.2 Workmanship

The size, thickness, colour, with or without designs etc of the tiles for flooring/dado/skirting shall be as specified in the respective items of work.

The total thickness of glazed tile finish including the bedding mortar shall be 20 mm in flooring/dado/skirting. The minimum thickness of bedding mortar shall be 12mm for flooring and 10mm for dado/skirting work.

The bedding mortar shall consist of 1 part of cement to 3 parts of sand mixed with just sufficient water to obtain proper consistency for laying. Sand for the mortar shall conform to IS: 2116 and shall have minimum fineness modulus of 1.5.

Tiles shall be soaked in water for about 10 minutes just before laying. Where full size tiles cannot be fixed, tiles shall be cut to the required size using special cutting device and the edges rubbed smooth to ensure straight and true joints.

Colored tiles with or without designs shall be uniform and shall be preferably procured from the same batch of manufacture to avoid any differences in the shade.

Tiles for the flooring shall be laid over hardened concrete base. The surface of the concrete base shall be cleaned of all loose materials, mortar droppings etc well wetted without allowing any water pools on the surface. The bedding mortar shall then be laid evenly over the surface, tamped to the desired level and allowed to harden for a day. The top surface shall be left rough to provide a good bond for the tiles. For skirting and dado work, the backing mortar shall be roughened using a wire brush.

Neat cement slurry using 3.3 kg cement per sq.m of floor area shall be spread over the hardened mortar bed over such an area as would accommodate about 20 tiles. Tiles shall be fixed in this slurry one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. For skirting and dado work, the back of the tiles shall be smeared with cement slurry for setting on the backing mortar. Fixing of tiles shall be done from the bottom of the wall upwards. The joints shall be in perfect straight lines and as thin as possible but shall not be more than 1mm wide. The surface shall be checked frequently to ensure correct level/required slope. Floor tiles near the walls shall enter skirting/dado to a minimum depth of 10mm. Tiles shall not sound hollow when tapped.

All the joints shall be cleaned of grey cement with wire brush to a depth of atleast 3mm and all dust, loose mortar etc. shall be removed. White cement with or without pigment shall then be used for flush pointing the joints. Curing shall then be carried out for a minimum period of 7 days for the bedding and joints to set properly. The surface shall then be cleaned using a suitable detergent, fully washed and wiped dry.

Specials consisting of coves, internal and external angles, cornices, beads and their corner pieces shall be of thickness not less than the tiles with which they are used.

8.18.3 Measurement

Measurement shall be as per Clause 8.14.3.

8.19 In-Situ Cement Concrete Floor Topping

8.19.1 Materials

The mix proportion for the in-situ concrete floor topping shall be 1:2.5:3.5 (one part cement: two and half parts sand: three and half parts coarse aggregates) by volume unless otherwise specified in the items of work.

The aggregates shall conform for the requirements of IS: 383.

Coarse aggregates shall have high hardness surface texture and shall consist of crushed rock of granite, basalt, trap or quartzite. The aggregate crushing valve shall not exceed 30 percent. The grading of the aggregates of size 12.5mm and below shall be as per IS: 2571.

Grading of the sand shall be within the limits indicated in IS: 2571.

8.19.2 Workmanship

The thickness of the floor topping shall be as specified in the items of work. The minimum thickness of the floor topping shall be 25mm.

Preparation of base concrete/structural slab before laying the topping shall be as per clause 8.13. The surface shall be rough to provide adequate bond for the topping.

Mixing of concrete shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by the Engineer. The concrete shall be as stiff as possible and the amount of water added shall be the minimum necessary to give just sufficient plasticity for laying and compacting. The mix shall be used in the work within 30 minutes of the addition of water for its preparation.

Floor finish shall be laid in suitable panels to reduce the risk of cracking. No dimension of a panel shall exceed 2 meters and the length of a panel shall not exceed one and a half times its breadth. Topping shall be laid in alternate panels, the intermediate panels being cast after a gap of atleast one day. Construction joints shall be plain vertical butt joints.

Screed strips shall be fixed dividing the area into suitable panels. Immediately before depositing the concrete topping, neat cement slurry at 2.75 kg/sq.m of area shall be thoroughly brushed into the prepared surface. Topping shall then be laid, very thoroughly tamped, struck off level and floated with wooden float. The surface shall then be tested with a straight edge and mason's spirit level to detect any inequalities and these shall be made good immediately.

Finishing of the surface by troweling shall be spread over a period of one to six hours depending upon the temperature and atmospheric conditions. The surface shall be trowelled 3 times at intervals so as to produce a smooth uniform and hard surface. Immediately after laying, the first trowelling just sufficient to give a level surface shall be carried out avoiding excessive trowelling at this stage. The surface shall be re- trowelled after sometime to close any pores and to scrap off excess water or laitance, which shall not be trowelled back into the topping. Final trowelling shall be done well before the concrete has become too hard but at a time when considerable pressure is required to make any impression on the surface. Sprinkling of dry cement or cement-sand mixture for absorbing moisture shall not be permitted.

Immediately after the surface is finished, it shall be protected suitably from rapid drying due to wind/ sunlight. After the surface has hardened sufficiently to prevent any damage to it, the topping shall be kept continuously moist for a minimum period of 10 days.

It is preferable to lay the topping on hardened base concrete, as against being laid monolithically with a lesser thickness, since proper levels and slopes with close surface tolerances is achievable in practice, owing to its greater thickness. Further, as this would be laid after all other building operations are over, there will be no risk of any damages or discoloration to the floor finish which are difficult to repair satisfactorily.

8.19.3 Measurement

Measurement shall be in sq.m correct upto two places of decimal.

8.20 In-Situ Granolithic Concrete Floor Topping

8.20.1 Materials and Workmanship

The requirements of materials and workmanship shall be all as per clause 8.19 for in-situ cement concrete floor topping except that the mix proportion of the concrete shall be 1:1:2 (cement:sand:coarse aggregates) by volume.

The minimum thickness of granolithic floor topping on hardened concrete base shall be 40mm.

8.20.2 Measurement

Measurement shall be in sq.m correct upto two places of decimal.

8.21 Floor Hardener Topping

8.21.1 Materials & Workmanship

Floor hardener topping shall be provided either as integrally finished over the structural slab/grade slab or laid monolithically with the concrete/granolithic floor finish on top of hardened concrete base.

Floor hardener of the metallic or non-metallic type suitable for the performance of normal / medium/ heavy duty function of the floor, the quantum of ingredients and the thickness of topping shall be as specified in the respective items of work.

For monolithic application with the floor finish/slab the thickness of the layer shall be 15mm. The topping shall be laid within 2 to 3 hours after concrete is laid when it is still plastic but stiffened enough for the workmen to tread over it by placing planks. The surface of the concrete layer shall be kept rough for providing adequate bond for the topping. Laitance shall be removed before placing the topping. The topping shall be screened and thoroughly compacted to the finished level. Trowelling to a smooth finish shall be carried out as per clause 8.19.2. After the surface has hardened sufficiently, it shall be kept continuously moist for atleast 10 days.

The procedure for mixing the floor hardener topping shall be as per manufacturer's instructions.

Surface shall be prevented from any damages due to subsequent building operations by covering with 75 mm thick layer of sand.

8.21.2 Measurement

Measurement shall be in sq.m correct to two places of decimal. This could be either separate or combined along with the floor finish as indicated in the respective items of work.

8.22 PVC Sheet/Tile Flooring

8.22.1 Materials

PVC floor covering shall be of either unbacked homogeneous flexible type in the form of sheets/tiles conforming to IS: 3462 or homogeneous PVC asbestos tiles conforming to IS:3461.

The surface of the sheets/tiles shall be free from any physical defects such as pores, blisters, cracks etc. which affects the appearance and serviceability. Tiles/ sheets shall meet with the tolerance limits in dimensions specified in the BIS. Contractor shall submit the test certificates, if so desired by the Engineer.

Each tile/sheet shall be legibly and indelibly marked with the name of the manufacturer or his trade mark, IS certificate mark, and batch number.

The adhesive to be used for laying the PVC flooring shall be rubber based and of the make as recommended and approved by the manufacturer of PVC sheets/tiles.

The type, size, colour, plain or mottled and the pattern shall be as specified in the respective items of work.

8.22.2 Workmanship

PVC floor covering shall be provided over an underbed of cement concrete floor finish over the base concrete or structural slab. It is essential that the sub-floor and the underbed are perfectly dry before laying the PVC flooring. This shall be ensured by methods of testing as stipulated in Appendix-A of IS: 5318.

The surface of the underbed shall have trowelled finish without any irregularities which creates poor adhesion. Surface shall be free of oil or grease and thoroughly cleaned of all dust, dirt and wiped with a dry cloth.

PVC sheets/tiles shall be brought to the temperature of the area in which they are to be laid by stacking in a suitable manner within or near the laying area for a period of about 24 hours. Where air-conditioning is installed, the flooring shall not be laid on the underbed until the A/C units have been in operation for atleast 7 days. During this period, the temperature range shall be between 20deg.C and 30deg.C and this shall be maintained during the laying operations and also for 48 hours thereafter.

Layout of the PVC flooring shall be marked with guidelines on the underbed and PVC tiles/sheets shall be first laid for trial, without using the adhesive, according to the layout.

The adhesive shall be applied by using a notched trowel to the surface of the underbed and to the backside of PVC sheets/tiles. When the adhesive has set sufficiently for laying, it will be tacky to the touch, which generally takes about 30 minutes. The time period need be carefully monitored since a longer interval will affect the adhesive properties. Adhesive shall be uniformly spread over only as much surface area at one time which can be covered with PVC flooring within the stipulated time.

PVC sheet shall be carefully taken and placed in position from one end onwards slowly so that the air will be completely squeezed out between the sheet and the background surface and no air pockets are formed. It shall then be pressed with a suitable roller to develop proper contact. The next sheet shall be laid edge to edge with the sheet already laid, so that there is minimum gap between joints. The alignment shall be checked after each row of sheet is completed and trimmed if considered necessary.

Tiles shall be laid in the same manner as sheets and preferably, commencing from the centre of the area. Tiles should be lowered in position and pressed firmly on to the adhesive with minimum gap between the joints. Tiles shall not be slided on the surface. Tiles shall be rolled with a light wooden roller of about 5kg to ensure full contact with the underlay. Work should be constantly checked to ensure that all four edges of adjacent tiles meet accurately.

Any excess adhesive which may squeeze up between sheets/tiles shall be wiped off immediately with a wet cloth. Suitable solvents shall be used to remove hardened adhesive.

A minimum period of 24 hours shall be given after laying for the development of proper bond of the adhesive. When the flooring is thus completed, it shall be cleaned with a wet cloth soaked in warm soap solution.

Metallic edge strips shall be used to protect the edges of PVC sheets/tiles which are exposed as in doorways/ stair treads.

Hot sealing of joints between adjacent PVC sheet flooring to prevent creeping of water through the joints shall be carried out, using special equipment as per manufacturer's instructions.

8.22.3 Measurement

Measurement shall be in sq.m correct to two places of decimal. The item could be either separate or as a combined item with the floor finish as specified in the respective items of work.

8.23 Acid Resisting Brick/Tiling Work

8.23.1 Materials

The ceramic unglazed vitreous acid resisting tiles shall conform to the requirements of IS: 4457. Acid resistant bricks shall conform to the requirements of IS: 4860.

The finished tile/brick when fractured shall appear fine grained in texture, dense and homogeneous. Tile/brick shall be sound, true to shape, flat, free from flaws and any manufacturing defects affecting their utility. Tolerance in dimensions shall be within the limits specified in the respective BIS.
The tiles/bricks shall be bedded and jointed using chemical resistant mortar of the resin type conforming to IS: 4832 (Part II). Method of usage shall generally be as per the requirements of IS: 4443.

8.23.2 Workmanship

The size and thickness of tiles/size and class of bricks for use in the flooring/skirting/dado shall be as specified in the respective items of work.

The resin shall have viscosity for readily mixing with the filler by manual methods. The filler shall have graded particles which permit joint thickness of 1.5 mm.

The base concrete surface shall be free from dirt and thoroughly dried. The surface shall be applied with a coat of bitumen primer conforming to IS:3384. The primed surface shall then be applied with a uniform coat of bitumen conforming to IS:1580. Tiles or bricks shall be laid directly without the application of bitumen, if epoxy or polyester resin is used for the mortar.

Just adequate quantity of mortar which can be applied within the pot life as specified by the manufacturer shall be prepared at one time for bedding and jointing. Rigid PVC/Stainless steel/chromium plated tools shall be used for mixing and laying.

For laying the floor 6 to 8 mm thick mortar shall be spread on the back of the tile/brick. Two adjacent sides of the tile/brick shall be smeared with 4 to 6 mm thick mortar. Tile/brick shall be pressed into the bed and pushed against the floor and with the adjacent tile/ brick, until the joint in each case is 2 to 3 mm thick. Excess mortar shall then be trimmed off and allowed to harden fully. Similar procedure shall be adopted for the work on walls by pressing the tile/brick against the prepared wall surfaces and only one course shall be laid at a time until the initial setting period.

The mortar joints shall be cured for a minimum period of 72 hours with 20 to 25% hydrochloric acid or 30 to 40% sulphuric acid. After acid curing, the joints shall be washed with water and allowed to thoroughly dry. The joints shall then be filled with mortar to make them smooth and plane. Acid curing is not required to be carried out if epoxy or polyester resin is used for the mortar.

Resin mortars are normally self curing. The area tiled shall not be put to use before 48 hours in case epoxy, polyester and furane type of resin is used for the mortar. If phenolic or cashewnut shell liquid resin is used for the mortar, the area tiled shall not be put to use for 7 to 28 days respectively, without heat treatment. This period shall be 2 to 6 days respectively, if heat treatment is given with infrared lamp.

8.23.3 Measurement

Measurement shall be in sq.m correct to two places of decimal for flooring/dado. Measurement shall be in running metres correct to two places of decimal for skirting of height as specified in the item of work.

8.24 Heavy Duty Abrasion Resistant Flooring

The type, quality, size, thickness, colour, etc., of the tile for flooring and skirting work shall be of the best quality approved by the Engineer. For this purpose, the Contractor shall provide the Engineer with necessary samples for this selection. Tiles shall be hardwearing, resistant to impact, resistant to abrasion, free from slipperiness and also resistant to attack by water, oils and greases.

8.25 Epoxy Lining Work

8.25.1 Materials

The epoxy resin and hardener formulation for laying of jointless lining work in floors and walls of concrete tanks/trenches etc shall be as per the requirements of IS: 9197.

The epoxy composition shall have the chemical resistance to withstand the following conditions of exposure:

a) Hydrochloric acid upto 30% concentration

b) Sodium hydroxide upto 50% concentration

c) Liquid temperature upto 60deg.C

d) Ultraviolet radiation

e) Alternate wetting and drying

Sand shall conform to grading zone III or IV of IS: 383.

The hardener shall be of the liquid type such as Aliphatic Amine or an Aliphatic/Aromatic Amine Adduct for the epoxy resin. The hardener shall react with epoxy resin at normal ambient temperature.

Contractor shall furnish test certificates for satisfying the requirements of the epoxy formulation if so directed by the Engineer.

8.25.2 Workmanship

The minimum thickness of epoxy lining shall be 4 mm. It is essential that the concrete elements are adequately designed to ensure that water is excluded to permeate to the surface, over which the epoxy lining is proposed.

The epoxy lining shall be of the trowel type to facilitate execution of the required thickness for satisfactory performance.

The concrete surfaces over which epoxy lining is to be provided shall be thoroughly cleaned of oil or grease by suitable solvents, wire brushed to remove any dirt/dust and laitance. The surfaces shall then be washed with dilute hydrochloric acid and rinsed thoroughly with plenty of water or dilute ammonia solution. The surfaces shall then be allowed to dry. It is essential to ensure that the surfaces are perfectly dry before the commencement of epoxy application.

Just adequate quantity of epoxy resin which can be applied within the pot life as specified by the manufacturer shall be prepared at one time for laying and jointing.

Rigid PVC/stainless steel/chromium plated tools shall be used for laying. Trowelling shall be carried out to obtain uniformly the specified thickness of lining.

Lining shall be allowed to set without disturbance for a minimum period of 24 hours. The facility shall be put to use only after a minimum period of 7 days of laying of the lining.

8.25.3 Measurement

Measurement shall be in sq.m correct to two places of decimal.

8.26 Water-Proofing

Machine made flat Yelahanka tiles shall be of the size and thickness as specified in the item of work. Tiles shall be soaked in water for atleast one hour before laying. The tiles shall be laid on a mortar bed of cement mortar 1:3 with an average thickness of 25mm. Tiles shall be laid, open jointed with 4 to 6 mm wide joints, flat on the mortar and lightly pressed and to set to plane surface true to slope, using trowel and wooden straight edge. They shall be laid with their longitudinal lines of joints truly parallel and generally at right angles to the direction on run-off gradient. Transverse joints in alternate rows shall come directly in line with each other. Transverse joints in adjacent courses shall break joints by atleast 50 mm. The joints shall be completely filled and flush pointed with cement mortar 1:3 mixed with red-oxide. Curing shall be carried out for a minimum period of seven days.

8.26.1 General

The work shall include waterproofing for the building roofs, terraces, toilets, floor slabs, walls, planters, chajjas, sills and any other areas and at any other locations and situations as directed by the Engineer.

The waterproofing treatment shall be carried out on top of lime concrete (brick bat coba) laid to slope on roof surfaces. The brick bat coba shall be covered as specified below.

The work shall be carried out by an experienced specialist Sub-Contractor who shall be appointed only after prior approval of the Engineer.

8.26.2 Modified Bituminous Membrane

Modified Bituminous Membrane shall be "SUPER THERMOLAY" 4 mm thick weighing 4 Kg/sqm, manufactured using APP Polymer modified bitumen with a central core of non-woven polyester reinforcement (200 gms/sqm) and with top and bottom layers of thermofusible film (top layer could also be sand finished) made by STP Limited in collaboration with Bitumat Company Limited. "PLYFLEX" of Bitumat Company Limited, Saudi Arabia supplied by STP Limited shall also be acceptable or other equivalent specification.

8.26.3 Waterproofing of Roofs with Lime Concrete

(a) Materials

Broken brick coarse aggregates prepared from well/over burnt bricks shall be well graded having a maximum size of 25mm and shall generally conform to IS:3068.

Lime shall be class C lime (fat lime) or factory made hydrated lime conforming to IS:712.

(b) Workmanship

Lime concrete shall be prepared by thoroughly mixing the brick aggregates inclusive of brick dust obtained during breaking with the slaked lime in the proportions of 2 1/2 (two and a half) parts of brick aggregates to 1 part of slaked lime by volume. Water shall be added just adequate to obtain the desired workability for laying. Washing soap and alum shall be dissolved in the water to be used. The quantity of these materials required per cum of lime concrete shall be 12kg of washing soap and 4kg of alum. Brick aggregates shall be soaked thoroughly in water for a period of not less than six hours before use in the concrete mix. Lime concrete shall be used in the works within 24 hours after mixing.

The roof surface over which the water-proof treatment is to be carried out shall be cleaned of all foreign matter by wire brushing, dusting and made thoroughly dry. Preparation of surfaces shall be as stipulated in IS: 3067.

The slope of the finished waterproofing treatment shall be not less than 1 in 60 for efficient drainage. This shall be achieved either wholly in the lime concrete layer or otherwise as indicated in the drawings.

The average thickness of lime concrete, slope and the finish on top of machine made burnt clay flat terracing tiles conforming to IS:2690 (part I) shall be as specified in the items of work. Cement concrete flooring tiles in lieu of clay terracing tiles shall be provided if so specified in the items of work, duly considering the traffic the terrace will be subjected to.

The minimum compacted thickness of lime concrete layer shall be 75mm and average thickness shall not be less than 100mm. In case, the thickness is more than 100mm, it shall be laid in layers not exceeding 100mm to 125mm.

Laying of lime concrete shall be commenced from a corner of the roof and proceeded diagonally towards centre and other sides duly considering the slopes specified for effectively draining the rain-water towards the downtake points.

Lime concrete fillet for a minimum height of 150mm shall be provided all along the junction of the roof surface with the brick masonry wall/parapet/column projections. These shall then be finished on top with provision of clay terracing tiles/cement concrete tiles.

After the lime concrete is laid it shall be initially rammed with a rammer weighing not more than 2 Kg and the finish brought to the required evenness and slope. Alternatively, bamboo strips may be used for the initial ramming. Further consolidation shall be done using wooden THAPIES with rounded edges. The beating will normally have to be carried on for at least seven days until the THAPI makes no impression on the surface and rebounds readily from it when struck. Special care shall be taken to properly compact the lime concrete at its junction with parapet walls or column projections.

During compaction by hand-beating, the surface shall be sprinkled liberally with lime water (1 part of lime putty and 3 to 4 parts of water) and a small proportion of sugar solution for obtaining improved water-proofing quality of the lime concrete. On completion of beating, the mortar that comes on the top shall be smoothened with a trowel or float, if necessary, with the addition of sugar solution and lime putty. The sugar solution may be prepared in any one of the following ways as directed by the Engineer.

a) By mixing about 3 Kg of Jaggery and 1.5 Kg of BAEL fruit to 100 litres of water.
b) By mixing about 600 gm of KADUKAI (the dry nuts shall be broken to small pieces and allowed to soak in water), 200 gm of jaggery and 40 litres of water for 10 sq.m of work. This solution shall be brewed for about 12 to 24 hours and the resulting liquor decanted and used for the work.

The lime concrete after compaction shall be cured for a minimum period of seven days or until it hardens by covering with a thin layer of straw or hessian which shall be kept wet continuously.

Machine made flat terracing tiles shall be of the size and thickness as specified. Tiles shall be soaked in water for at least one hour before laying. Bedding for the tiles shall be 12mm thick in cement mortar 1:3. Tiles shall be laid, open jointed with 4 to 6 mm wide joints, flat on the mortar and lightly pressed and set to plane surface true to slope, using a trowel and wooden straight edge. They shall be laid with their longitudinal lines of joints truly parallel and generally at right angles to the direction of run-off gradient. Transverse joints in alternate rows shall come directly in line with each other. Transverse joints in adjacent courses shall break joints by atleast 50 mm. The joints shall be completely filled and flush pointed with cement mortar 1:2 mixed with water proofing compound as per manufacturer's instructions. Curing shall be carried out for a minimum period of seven days.

Finishing on top with cement concrete tiles or in-situ cement concrete floor topping shall be carried out in similar fashion as described for clay tiles in above the paragraph. Tiles to be used shall be supplied after the first machine grinding of the surface.

8.26.4 Measurement

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be for the plan area where the treatment is executed. No separate payment shall be made for the fillets.

8.26.5 Waterproofing of Roofs/Terraces etc.

(a) Water proofing of Horizontal Surfaces

The waterproofing shall be applied as follows:

A coat of Blown Bitumen 85/25 shall be applied at the rate of 1.45 kg/sq.km

A roll of Modified Bituminous Membrane shall be unrolled over the primed surface and completely bonded to the substrate by pressing down evenly for the full width of the roll using a wooden roller. Torching shall be done, where recommended by the manufacturer and where directed by the Engineer-in-Charge, as the unrolling progresses.

The side overlaps shall be minimum 100 mm whereas the end overlaps shall be minimum 150 mm; both shall be bonded and sealed by flame torching.

Care shall be taken that the membrane is lapped with the treatment along the vertical surface and roof gutter treatment for at least 500 mm.

The membrane shall be properly overlapped/terminated at all openings, rainwater downtakes etc. to ensure that such junctions do not become sources of leakage.

Top of membrane finally shall be painted with antiglouse reflective paint.

(b) Waterproofing of Vertical Surfaces at Roof Level and Gutters

The Water proofing shall be applied as described in (a) above.

Modified Bituminous membrane shall be unrolled and bonded to the substrate after applying a coat of bitumen and by pressing down evenly for the full width of the roll. Light torching shall be done to ensure complete bonding.

The membrane shall be overlapped with treatment for the horizontal surface by at least 500 mm.

The membrane shall be taken upto a pre-cut chase anchored and sealed.

8.26.6 Khurras and Rainwater Down Pipes

Down pipes shall be isolated from RCC work with 6 mm polyethylene foam fixed with adhesive (Araldite) and sealed with silicone sealant prior to laying membrane. A water proofing flashing composed of one layer of Hessian based self finished felt Type 3 Grade 1 and two layers of aluminium foil of 0.075 mm thickness shall be provided. This flashing shall be carried into the down take pipes for at least 150 mm and sealed with hot bitumen. The Contractor shall closely coordinate the work with the agency providing and fixing the rainwater down take pipes.

8.26.7 Testing

The treated area (flat and horizontal only) shall be tested by allowed water to stand on the treated areas to a depth of 150 mm for a minimum period of 72 hours.

The treated area (flat and horizontal) shall have continuous slope towards the rainwater outlets and no water shall pond any where on the surface.

8.27 Cement Plastering Work

8.27.1 Materials

The proportions of the cement mortar for plastering shall be 1:4 (one part of cement to four parts of sand). Cement and sand shall be mixed thoroughly in dry condition and then just enough water added to obtain a workable consistency. The quality of water and cement shall be as per relevant BIS standards. The quality and grading of sand for plastering shall conform to IS: 1542. The mixing shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by the Engineer. If so desired by the Engineer sand shall be screened and washed to meet the Specifications. The mortar thus mixed shall be used as soon as possible preferably within 30 minutes from the time water is added to cement. In case the mortar has stiffened due to evaporation of water this may be re-tempered by adding water as required to restore consistency but this will be permitted only upto 30 minutes from the time of initial mixing of water to cement. Any mortar which is partially set shall be rejected and removed forthwith from the site. Droppings of plaster shall not be re-used under any circumstances.

8.27.2 Workmanship

Preparation of surfaces and application of plaster finishes shall generally conform to the requirements specified in IS: 1661 and IS: 2402.

Plastering operations shall not be commenced until installation of all fittings and fixtures such as door/window panels, pipes, conduits etc. are completed.

All joints in masonry shall be raked as the work proceeds to a depth of 10mm/20mm for brick/stone masonry respectively with a tool made for the purpose when the mortar is still green. The masonry surface to be rendered shall be washed with clean water to remove all dirt, loose materials, etc., Concrete surfaces to be rendered shall be roughened suitably by hacking or bush hammering for proper adhesion of plaster and the surface shall be evenly wetted to provide the correct suction. The masonry surfaces should not be too wet but only damp at the time of plastering. The dampness shall be uniform to get uniform bond between the plaster and the masonry surface.

Interior plain faced plaster - This plaster shall be laid in a single coat of 12mm thickness. The mortar shall be dashed against the prepared surface with a trowel. The dashing of the coat shall be done using a strong whipping motion at right angles to the face of the wall or it may be applied with a plaster machine. The coat shall be trowelled hard and tight forcing it to surface depressions to obtain a permanent bond and finished to smooth surface. Interior plaster shall be carried out on jambs, lintel and sill faces, etc. as shown in the drawing and as directed by the Engineer.

Plain Faced Ceiling plaster - This plaster shall be applied in a single coat of 12mm thickness. Application of mortar shall be as stipulated in above paragraph.

Exterior plain faced plaster - This plaster shall be applied in 2 coats. The first coat or the rendering coat shall be approximately 12mm thick. The rendering coat shall be applied as stipulated above except finishing it to a true and even surface and then lightly roughened by cross scratch lines to provide bond for the finishing coat. The rendering coat shall be cured for atleast two days and then allowed to dry. The second coat or finishing coat shall be 8 mm thick. Before application of the second coat, the rendering coat shall be evenly damped. The second coat shall be applied from top to bottom in one operation without joints and shall be finished leaving an even and uniform surface. The mortar proportions for the coats shall be as specified in the respective item of work. The finished plastering work shall be cured for atleast 7 days.

Interior plain faced plaster 20mm thick if specified for uneven faces of brick walls or for random/coursed rubble masonry walls shall be executed in 2 coats similar to the procedure stipulated in above paragraph.

Exterior Sand Faced Plaster- This plaster shall be applied in 2 coats. The first coat shall be approximately 12mm thick and the second coat shall be 8mm thick. These coats shall be applied as stipulated above. However, only approved quality white sand shall be used for the second coat and for the finishing work. Sand for the finishing work shall be coarse and of even size and shall be dashed against the surface and sponged. The mortar proportions for the first and second coats shall be as specified in the respective items of work.

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Wherever more than 20mm thick plaster has been specified, which is intended for purposes of providing beading, bands, etc. this work shall be carried out in two or three coats as directed by the Engineer duly satisfying the requirements of curing each coat (rendering/floating) for a minimum period of 2 days and curing the finished work for atleast 7 days.

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In the case of pebble faced finish plaster, pebbles of approved size and quality shall be dashed against the final coat while it is still green to obtain as far as possible a uniform pattern all as directed by the Engineer.

Where specified in the drawings, rectangular grooves of the dimensions indicated shall be provided in external plaster by means of timber battens when the plaster is still in green condition. Battens shall be carefully removed after the initial set of plaster and the broken edges and corners made good. All grooves shall be uniform in width and depth and shall be true to the lines and levels as per the drawings.

Curing of plaster shall be started as soon as the applied plaster has hardened sufficiently so as not to be damaged when watered. Curing shall be done by continuously applying water in a fine spray and shall be carried out for at least 7 days.

For waterproofing plaster, the Contractor shall provide the water-proofing admixture as specified in manufacturers instruction while preparing the cement mortar.

For external plaster, the plastering operations shall be commenced from the top floor and carried downwards. For internal plaster, the plastering operations for the walls shall commence at the top and carried downwards. Plastering shall be carried out to the full length of the wall or to natural breaking points like doors/windows etc. Ceiling plaster shall be completed first before commencing wall plastering.

Double scaffolding to be used shall be as specified in clause 8.2.2.

The finished plaster surface shall not show any deviation more than 4mm when checked with a straight edge of 2m length placed against the surface.

To overcome the possibility of development of cracks in the plastering work following measures shall be adopted.

a) Plastering work shall be deferred as much as possible so that fairly complete drying shrinkage in concrete and masonry works takes place.
b) Steel wire fabric shall be provided at the junction of brick masonry and concrete to overcome reasonably the differential drying shrinkage/thermal movement.
c) Ceiling plaster shall be done, with a trowel cut at its junction with wall plaster. Similarly trowel cut shall be adopted between adjacent surfaces where discontinuity of the background exists.

8.27.3 Measurement

Measurement for plastering work shall be in sq.m correct to two places of decimal. Unless a separate item is provided for grooves, mouldings, etc., these works are deemed to be included in the unit rates quoted for plastering work. The quantity of work to be paid for under these items shall be calculated by taking the projected surface of the areas plastered after making necessary deductions for openings for

doors, windows, fan openings etc. The actual plaster work carried out on jambs/sills of windows, openings, etc. shall be measured for payment.

8.28 Cement Pointing

8.28.1 Materials

The cement mortar for pointing shall be in the proportion of 1:3 (one part of cement to three parts of fine sand). Sand shall conform to IS: 1542 and shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by Engineer and if so directed it shall be washed/screened to meet specification requirements.

8.28.2 Workmanship

Where pointing of joints in masonry work is specified, the joints shall be raked at least 15mm/20mm deep in brick/stone masonry respectively as the work proceeds when the mortar is still green.

Any dust/dirt in the raked joints shall be brushed out clean and the joints shall be washed with water. The joints shall be damp at the time of pointing. Mortar shall be filled into joints and well pressed with special steel trowels. The joints shall not be disturbed after it has once begun to set. The joints of the pointed work shall be neat. The lines shall be regular and uniform in breadth and the joints shall be raised, flat, sunk or 'V' as may be specified in the respective items of work. No false joints shall be allowed.

The work shall be kept moist for atleast 7 days after the pointing is completed. Whenever coloured pointing has to be done, the colouring pigment of the colour required shall be added to cement in such proportions as recommended by the manufacturer and as approved by the Engineer.

8.28.3 Measurement

The quantity of work to be paid for under this item shall be measured in sq.m. Correct to two places of decimal by taking the projected surface of the area pointed after making necessary deductions for openings, etc.

8.29 Metal Lath and Wire Fabric

8.29.1 Materials

Welded steel wire fabric shall conform to IS: 4948.
Expanded metal shall conform to IS: 412.
Galvanised wire mesh shall be of approved quality.

8.29.2 Workmanship

The type and details of the steel material to be used for metal lath plastering work and at the junctions of brick masonry/concrete before wall plastering shall be as specified in the respective items of work.

For metal lath plastering work, the weight of steel material shall be not less than 1.6 kg/sq.m.

Steel material for use at the junction of brick masonry/concrete shall have the mesh dimensions not greater than 50 mm.

Steel material shall be obtained in maximum lengths as manufactured to restrict joints to the minimum. Overlap at the joints shall be minimum 25 mm which shall be securely tied with wires of diameter not less than 1.25 mm at spacings not more than 100 mm for lath plastering work. Nailing to wall shall be

at spacings not exceeding 200 mm. The material shall be straightened, cut and bent to shape if required for fixing as per the details indicated in the drawings.

8.29.3 Measurement

Measurement shall be in sq.m correct to two places of decimal for the type as specified in the respective items of work.

8.30 Water-Proofing Admixtures

Water-proofing admixture shall conform to the requirements of IS: 2645 and shall be of approved manufacture. The admixture shall not contain calcium chloride. The quantity of the admixture to be used for the works and method of mixing etc. shall be as per manufacturer's instructions and as directed by the Engineer.

8.31 Painting of Concrete, Masonry & Plastered Surfaces

8.31.1 Materials

Oil bound distemper shall conform to IS: 428. The primer shall be alkali resistant primer of the same manufacture as that of the distemper.

Cement paint shall conform to IS: 5410. The primer shall be a thinned coat of cement paint.

Lead free acid, alkali and chlorine resisting paint shall conform to IS: 9862.

White wash shall be made from good quality fat lime conforming to IS: 712. It shall be slaked at site and mixed with water in the proportion of 5 litres of water to 1 kg of unslaked lime stirred well to make a thin cream. This shall be allowed to stand for a minimum period of one day and strained through a clean coarse cloth. Four kg of gum dissolved in hot water shall be added to each cum of cream. 1.30 kg of sodium chloride dissolved in hot water shall then be added per 10 kg of lime used for the white wash to be ready for application.

Colour wash shall be made by addition of a suitable quantity of mineral pigment, not affected by lime, to the prepared white wash to obtain the shade/tint as approved by the Engineer.

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Engineer for the brand of manufacture and the colour/shade. All materials shall be brought to the site of works in sealed containers.

8.31.2 Workmanship

Contractor shall obtain the approval of the Engineer regarding the readiness of the surfaces to receive the specified finish, before commencing the work on painting.
Painting of new surfaces shall be deferred as much as possible to allow for thorough drying of the sub-strata.

The surfaces to be treated shall be prepared by thoroughly brushing them free from dirt, mortar droppings and any loose foreign materials. Surfaces shall be free from oil, grease and efflorescence. Efflorescence shall be removed only by dry brushing of the growth. Cracks shall be filled with Gypsum. Workmanship of painting shall generally conform to IS: 2395.

Surfaces of doors, windows etc. shall be protected suitably to prevent paint finishes from splashing on them.

8.31.3 White Wash

The prepared surfaces shall be wetted and the finish applied by brushing. The operation for each coat shall consist of a stroke of the brush first given horizontally from the right and the other from the left and similarly, the subsequent stroke from bottom upwards and the other from top downwards, before the first coat dries. Each coat shall be allowed to dry before the next coat is applied. Minimum of 2 coats shall be applied unless otherwise specified. The dry surface shall present a uniform finish without any brush marks.

8.31.4 Colour Wash

Colour wash shall be applied in the same way as for white wash. A minimum of 2 coats shall be applied unless otherwise specified. The surface shall present a smooth and uniform finish without any streaks. The finished dry surface shall not show any signs of peeling/powdery and come off readily on the hand when rubbed.

8.31.5 Cement Paint

The prepared surfaces shall be wetted to control surface suction and to provide moisture to aid in proper curing of the paint. Cement paint shall be applied with a brush with stiff bristles. The primer coat shall be a thinned coat of cement paint. The quantity of thinner shall be as per manufacturer's instructions. The coats shall be vigorously scrubbed to work the paint into any voids for providing a continuous paint film free from pinholes for effective water proofing in addition to decoration. Cement paint shall be brushed in uniform thickness and the covering capacity for two coats on plastered surfaces shall be 3 to 4 kg/sq.m. A minimum of 2 coats of the same colour shall be applied. Atleast 24 hours shall be left after the first coat to become sufficiently hard before the second coat is applied. The painted surfaces shall be thoroughly cured by sprinkling with water using a fog spray at least 2 to 3 times a day. Curing shall commence after about 12 hours when the paint hardens. Curing shall be continued for atleast 2 days after the application of final coat. The operations for brushing each coat shall be as detailed above.

8.31.6 Oil bound Distemper

The prepared surfaces shall be dry and provided with one coat of alkali resistant primer by brushing. The surface shall be finished uniformly without leaving any brush marks and allowed to dry for atleast 48 hours. A minimum of two coats of oil bound distemper shall be applied, unless otherwise specified. The first coat shall be of a lighter tint. Atleast 24 hours shall be left after the first coat to become completely dry before the application of the second coat. Broad, stiff, double bristled distemper brushes shall be used for the work. The operations for brushing each coat shall be as detailed above.

8.31.7 Acid, Alkali Resisting Paint

A minimum of 2 coats of acid/alkali resisting paint shall be applied over the prepared dry surfaces by brushing. Primer coat shall be as per manufacturer's instructions

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8.31.8 Plastic Emulsion Paint

The prepared surface shall be dry and provided with one coat of primer which shall be a thinned coat of emulsion paint. The quantity of thinner shall be as per manufacturer's instructions. The paint shall be laid on evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard for the first time over and then brushing alternately in opposite directions two or three times and then finally brushing lightly in a direction at right angles. In this process, no brush marks shall be left after the laying off is finished.

The full process of crossing and laying off constitutes one coat. The next coat shall be applied only after the first coat has dried and sufficiently become hard which normally takes about 2 to 3 hours. A minimum of 2 finishing coats of the same colour shall be applied unless otherwise specified. Paint may also be applied using rollers. The surface on finishing shall present a flat velvety smooth finish and uniform in shade without any patches.

8.31.9 Acrylic Emulsion Paint

Acrylic emulsion paint shall be applied in the same way as for plastic emulsion paint. A minimum of 2 finishing coats over one coat of primer shall be provided unless otherwise specified.

8.31.10 Measurement

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be for the areas as executed duly deducting for any openings etc. Rate quoted shall take into account the provision of necessary enabling works such as scaffolding, painter's cradle etc.

8.32 Painting & Polishing of Wood Work

8.32.1 Materials

Wood primer shall conform to IS: 3536.
Filler shall conform to IS: 110.
Varnish shall conform to IS: 337.
French polish shall conform to IS: 348.
Synthetic enamel paint shall conform to IS: 2932.

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Employer's Representative for the brand of manufacture and the colour/shade.

All materials shall be brought to the site of works in sealed containers.

8.32.2 Workmanship

The type of finish to be provided for woodwork of painting or polishing, the number of coats, etc. shall be as specified in the respective items of work to be prepared by the Contractor.

Primer and finish paint shall be compatible with each other to avoid cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

Painting shall be either by brushing or spraying. Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirements of IS: 2338 (Part I).

All the wood surfaces to be painted shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it across the grains and dusted off. Wood primer coat shall then be applied uniformly by brushing. The number of primer coats shall be as specified in the item of work to be prepared by the Contractor. Any slight irregularities of the surface shall then be made- up by applying an optimum coat of filler conforming to IS: 110 and rubbed down with an abrasive paper for obtaining a smooth surface for the undercoat of synthetic enamel paint conforming to IS:2932. Paint shall be applied by brushing evenly and smoothly by means of crossing and laying off in the direction of the grain of wood. After drying, the coat shall be carefully rubbed down using very fine grade of sand paper and wiped clean before the next coat is applied. Atleast 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the Employer's Representative. The number of coats of paint to be applied shall be as specified in the item of work to be prepared by the Contractor.

All the wood surfaces to be provided with clear finishes shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it in the direction of the grains and dusted off. Any slight irregularities of the surface shall be made up by applying an optimum coat of transparent liquid filler and rubbed down with an abrasive paper for obtaining a smooth surface. All dust and dirt shall be thoroughly removed. Over this prepared surface, varnish conforming to IS:337 shall be applied by brushing. Varnish should not be retouched once it has begun to set. Staining if required shall be provided as directed by the Employer's Representative. When two coats of varnish is specified, the first coat should be a hard-drying undercoat or flatting varnish which shall be allowed to dry hard before applying the finishing coat. The number of coats to be applied shall be as specified. For works where clear finish of French polish is specified the prepared surfaces of wood shall be applied with the polish using a pad of woolen cloth covered by a fine cloth. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles to give an even finish over the entire area. The surface shall be allowed to dry before applying the next coat. Finishing shall be carried out using a fresh clean cloth over the pad, slight dampening with methylated spirit and rubbing lightly and quickly in circular motions. The finished surface shall have a uniform texture and high gloss. The number of coats to be applied shall be as specified.

8.33 Painting of Steel Work

8.33.1 Materials

Red-oxide – zinc chrome primer shall conform to IS: 2074.
Synthetic enamel paint shall conform to IS: 2932.
Aluminium paint shall conform to IS: 2339.

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Employer's Representative for the brand of manufacture and the colour/shade. All the materials shall be brought to the site in sealed containers.

8.33.2 Workmanship

Painting work shall be carried out only on thoroughly dry surfaces. Painting shall be applied either by brushing or by spraying. Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirement of IS: 1477 (Part 2).

The type of paint, number of coats etc. shall be as specified in the respective items of work.

Primer and finish paint shall be compatible with each other to avoid cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

All the surfaces shall be thoroughly cleaned of oil, grease, dirt, rust and scale. The methods to be adopted using solvents, wire brushing, power tool cleaning etc., shall be as per IS: 1477 (Part – I) and as indicated in the item of work.

It is essential to ensure that immediately after preparation of the surfaces, the first coat of red oxide-zinc chrome primer shall be applied by brushing and working it well to ensure a continuous film without holidays. After the first coat becomes hard dry, a second coat of primer shall be applied by brushing to obtain a film free from `holidays'.

After the second coat of primer is hard dry, the entire surface shall be wet rubbed cutting down to a smooth uniform surface. When the surface becomes dry, the undercoat of synthetic enamel paint of optimum thickness shall be applied by brushing with minimum of brush marks. The coat shall be allowed to hard-dry. The under coat shall then be wet rubbed cutting down to a smooth finish, taking

adequate care to ensure that at no place the undercoat is completely removed. The surface shall then be allowed to dry.

The first finishing coat of paint shall be applied by brushing and allowed to hard-dry. The gloss from the entire surface shall then be gently removed and the surface dusted off. The second finishing coat shall then be applied by brushing.

Atleast 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the Employer's Representative.

8.34 Flashing

8.34.1 Materials

Anodised Aluminium sheets shall be 1.00mm thick with anodic film thickness of 0.025 mm.

Galvanised mild steel sheets shall be 1.00mm thick with zinc coating of 800 gms/sq.m.

Bitumen felt shall be either Hessian base self finished bitumen felt Type-3 Grade I conforming to IS:1322 or glass fibre base self finished felt Type-2 Grade 1 conforming to IS:7193.

8.34.2 Workmanship

The type of the flashing and method of fixing shall be as specified.

Flashing shall be of the correct shape and size as indicated in the construction drawings and they shall be properly fixed to ensure their effectiveness.

Flashing shall be of long lengths so as to provide minimum number of joints. The minimum overlap at joints shall be 100mm.

Fixing of the flashing shall be either by bolting with bitumen washers or by tucking into the groove 75 mm wide x 65 mm deep in masonry/concrete along with cement mortar 1:4 filletting as indicated in the Drawings. Curing of the mortar shall be carried out for a minimum period of 4 days.

Bitumen felt flashing of the type as specified shall be provided with 2 coats of bituminous paint at the rate of 0.10 litre/sq.m after the installation.

8.34.3 Measurement

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be for the actual area of the flashing material provided and the rate shall include for all the incidental works of bending to shape and fixing details as per the construction drawings.

8.35 Thermal Insulation For Ceiling

Thermal insulation shall be "Thermocole" TF type or similar approved or Resin bonded fibre glass boards.

8.35.1 Fixing

8.35.2 "Thermocole" Boards

Soffit of R.C. slab shall be thoroughly cleaned with wire brush and 85/25 industrial grade hot bitumen conforming to IS: 702 shall be applied uniformly over the surface at the rate of 1.5 Kg/m^2.

Thermocole boards (T.F. variety) of 50mm thickness shall be stuck by means of the same grade of hot bitumen.

The boards shall be further secured with screws, washers and plugs.

The joints of the boards shall be sealed with bitumen.

8.35.3 Fibre Glass Boards

Timber pegs 50mm x 50mm x 50mm shall be fixed to the slab at 600mm centres with 6mm x 65mm long wood screws. 20 gauge G.I. lacing wire shall be tied to the pegs.

`Crown‟ 200 fibreglass boards 50mm thick shall be stuck to the pegs with CPRX compound or any other suitable adhesive and be held in position by the 20 gauge G.I. lacing wires.

The insulation boards shall be covered with 20mm – 24 gauge hexagonal G.I. chicken wire mesh, nailed to the timber pegs and 30 gauge aluminium sheets shall be fixed over the chicken wire mesh with 50mm overlap and secured to the timer pegs by screws.

If the insulation is specified to rest on top of the false ceiling, it shall be properly installed and anchored to the framework. In case additional battens are required for proper installation, Contractor shall include its cost in the rate for insulation.

8.35.4 Measurement

The net superficial area of the insulation shall be measured and paid for.

8.36 Plaster of Paris Board False Ceiling

8.36.1 Plaster of Paris Boards

The plaster of paris boards to be used in the false ceiling shall be of an approved manufacture or manufactured at site by methods and materials approved by Engineer.

The plaster of paris shall be of the calcium-sulphate hemi-hydrate variety and shall contain not less than 35 percent sulphur trioxide and other requirements as per IS:2547 (Part I) However, its fineness shall be such that the residue, after drying, and sieving on I.S. sieve designation 3.35mm for 5 minutes shall not be more than 1 percent by weight. Initial setting time shall not be less than 13 minutes. The average compressive strength of plaster determined by testing 5 cm cubes 24 hours after removal from moulds and drying in an oven at 40 Deg. C till the weight of the cubes is constant, shall not be less than 84 kg per sq.cm.

The plaster of paris boards reinforced with hessian cloth or coir shall be prepared in suitable sizes as shown on the drawings or as directed by the Engineer. Wooden forms of height equal to the thickness of boards shall be placed on truly level and smooth surface such as a glass sheet. The edges of the boards shall be truly square. The glass sheet or surface on which form is kept and the form sides shall be given a thin coat of non-staining oil to facilitate the easy removal of the board. Plaster of paris shall be evenly spread into the form upto about half the depth and hessian cloth or coir shall be pressed over the plaster of paris layer. The weight of hessian cloth or coir in the board shall be 250 gm per sq.m. The ends of the hessian/coir reinforcement shall be turned over at all edges to form a double layer for a width of 50mm. The hessian cloth shall be of an open web texture so as to allow the plaster below and above to intermix with each other and form an integral board. The form shall then be filled with plaster of paris which shall be uniform pressed and then wire cut to an even and smooth surface. The board shall then be allowed to set initially for an hour or so and then removed from the form and allowed to dry and harden for about a week. The board after drying and hardening

shall give a ringing sound when struck. The boards shall be true and exact to shape and size and the exposed face shall be truly plane and smooth.

The size of boards shall generally be 600mm x 600 mm x 12 mm thick. Boards shall be kept dry in transit and stored flat in a clean dry place and shall not be exposed to moisture. The boards shall always be carried on edges.

8.36.2 Metal Framework

The metal frame work may be made of sections of light metal, such as anodised aluminium, mild steel or as shown on the drawings. The shape of cross-section shall be such as to facilitate proper suspension and proper fixing of the ceiling boards covering them and shall be structurally sound and rigid.

8.37 Construction

Contractor shall ensure that the frame to support the ceiling is designed for structural strength and the sizes, weight and strength of ceiling boards to be fixed and other loads due to live load, air-conditioning ducts, grills, electrical wiring and lighting fixtures, thermal insulation, etc. as shown on the drawings. Contractor shall also submit a detailed drawing to show the grid work, sizes of grid members, method of suspension, position of openings for air-conditioning and lighting, access doors, etc.

The false ceiling grid work shall be carried out as per the approved drawings or as directed by Engineer. In case of timber grid work, the grid work shall consist of teak wood runners of minimum size 60mm deep x 40mm wide along one direction at 1.2m centre to centre and secondary runners of size 50mm deep x 40 mm wide at 60mm centre to centre perpendicular to the main runners.

The metal frame work when it is anodised aluminium false ceiling grid system shall consist of aluminium main member of special T-Profile of 38mm x 38mm x 1.5mm thick, interlocking with each other to form frames of various sizes, 600mm x 600 mm or as shown on the drawing. The main members shall be suspended from the roof structures by means of steel hangers as described for timber frame work and supported at the walls by means of anodised aluminium wall angles.

In the case of timber frame work, all the edges of the plaster of paris board shall be fixed to frame members by means of counter sunk and rustless screws of 2.74 mm size, 40mm long at a spacing of 100mm to 150 mm c/c and 12mm from the edge of the board. Holes for screws shall be drilled and screws slightly countersunk into the boards. The boards shall be fixed to wooden framework with a joint clearance of about 3mm. The joints shall always be in perfect line and plane.

In case of aluminium grid system, boards shall be just placed into the frames formed by the main `T" members and the cross members fitted with the clips for locking boards. Contractor shall take utmost care so as not to force the boards in position and a slight gap shall be provided so as not to make a tight joint. The boards shall be cut with a saw, if required, to any shape and size.

As the work of false ceiling may be inter-connected with the work of air-conditioning ducts and lighting, Contractor shall fully co-operate with the other agencies entrusted with the above work, who may be working simultaneously. Contractor shall provide necessary openings in the false ceiling work for air-conditioning, lighting and other fixtures. Additional framing, if required, for the above opening shall also be provided at no extra cost to the Employer. Removable or hinged type inspection or access trap doors shall be provided at locations specified by the Engineer.

8.37.1 Finishing

It is essential that false ceiling work should be firm and in perfect line and level and all boards free from distortion, bulge, and other defects. All defective boards and other material shall be removed

from site immediately and replaced, and ceiling restored to original finish to the satisfaction of Engineer.

The workmanship shall be of highest order and all joinery work for timber work shall be in the best workmanship manner. The joints for aluminium frame work shall be of inter-locking type so that when the cross member is in place, it cannot be lifted out.

The countersunk heads of screws and all joints shall be filled with plaster of paris and finished smooth. After filling the joints, a thick skin of the finishing material shall be spread about 50mm wide on either side of the joint and on to it shall be trowelled dry a reinforcing scrim cloth about 10mm wide. If metal scrim is used, a stiffer plaster will be necessary to enable the trowelling of the scrim down to the board.

8.37.2 Fire Stopping

In case of fire protective ceilings, fire resisting barriers at suitable intervals shall be provided . These shall completely close the gap between the false ceiling and soffit of the structural slab. The material of thebarrier shall be as indicated by Engineer (Reference may be made to the British Standards Institutions CP 290: Code of Practice for suspended ceiling and lining of dry construction using metal fixing system, `for guidance).

8.37.3 Measurement and Payment

The superficial area of false ceiling shall be measured and paid for at the unit rate less deductions, if any. Openings in false ceiling which are less than 0.4 sq.m. in area shall not be deducted for the purpose of payment.

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The quoted rates shall include supply, delivery and erection of all materials for covering the ceiling, frame work suspenders or hangers, anti-termite treatment making openings in false ceiling, extra frame work required for the openings, supporting the main members on masonry walls, levelling and finishing complete.

Where moulding or beading is specified, it shall be as per details shown in drawings and shall be measured in running metres and paid for separately.

Where fire barriers are specified, they shall be as per details shown in drawings and as directed and shall be measured in square metres and paid for separately.

8.38 False or Cavity Floor

8.38.1 Frame Work

The false floor shall consist of a framework of suitable structural member designed to carry the loads specified. This frame work shall be supported on suitably designed stools placed at 600mm centre to centre in both directions. The stools shall consist of a mild steel base plate with a mild steel stud having adjustable lock nut and coupling at the centre and another mild steel plate at top serving as a prophead. The above framework shall be suitably designed to accommodate 35mm thick, 600mm square panels. The base plate shall be fixed to the reinforced concrete floor with an approved adhesive compound or with 4 Nos. 6mm dia. anchor fasteners. Bedding of 1:2 or richer cement sand mortar shall be provided locally under the base plates of stools to provide a level surface.

The prophead shall be provided with mild steel lugs welded on top and each placed perpendicular to the other for proper positioning and supporting the main and cross members. The stools shall be capable of adjustment to accommodate concrete floor level irregularities upto plus or minus 15mm. The framing members shall be completely removable and shall remain in position without screwing or

bolting to the propheads. All steel framework including steel stools shall be given a coat of zinc chromate primer and two coats of enamel paint of approved colour and shade.

8.38.2 Floor Panels

The floor panels shall be made of 600mm x 600mm x 35 mm thick medium density unveneered/ non-prelaminated teak wood particle boards having a density of not more than 800 kg/cum bonded with boiling water proof phenol formaldehyde synthetic resin and shall be of fire resistant, termite resistant and moisture proof quality, generally conforming to IS: 3087-specification for wood particle boards (Medium Density) for general purposes.

The thermal conductivity of the boards shall not exceed 0.12 k Cal/hr/sq.m/deg./C/m.

The panel size given above may be suitably modified near electrical panel/equipment and also to suit room dimensions with panel size not more than 600mm under any circumstances. Exposed 2mm thick vinyl edging shall be provided on all edges of individual panels. Each panel shall be given a coat or primer and two coats of approved fire resistant paint from underside.

The particle boards shall be faced with 600mm x 600 mm x 2mm thick approved make flooring tiles conforming to IS:3462 and of approved colour and shade. The completed panel shall be completely removable and shall remain in position without screwing or bolting to the supporting framework. Each floor panel shall be marked on the inner side with stickers for easy identification and reassembly whenever required.

Suitable backing material shall be provided on the underside of the particle board to prevent warping and / or to cater to specified loading.

Suitable removable covers shall be provided to serve as outlets for the cables.

8.38.3 Finished Height of False Flooring

The finished height from top of reinforced concrete floor to the finished floor surface of false/cavity floor shall be as specified or as shown on drawings.

8.38.4 Ramps and Steps

Ramps and steps shall be provided as shown on the Engineer's drawing and as directed by the Engineer without any extra cost to the Employer.

8.38.5 Imposed Loading

The finished floor shall be capable of supporting a uniformly distributed loads of 500 to 1000 Kg. per sq.metre of floor area as specified in data sheet. A point load of 450 Kg on 600 sq.mm on any part of the panel or a line load of 725 Kg on 100mm strip across the panel length shall not result in a deflection greater than 2.5mm.

8.38.6 Finish

The finished floor shall be true to lines and levels and present a neat flush surface.

8.38.7 General

Supply shall be made by a specialist supplier who is to be approved by Engineer. Supplier shall prepare and submit a layout drawing for false floor giving all details including supporting system for approval. If so called for, supplier shall also submit his calculations for the supporting system with all

relevant data assumed, to the Engineer for his approval. Work shall be carried out on approved drawings only.

8.38.8 Measurement

The superficial area of false floor shall be measured and paid for at the quoted unit rate.

8.39 Vendor Drawing

Vendor shall prepare and submit a layout drawing for false floor giving all details including supporting system for approval. If so called for, vendor shall also submit his calculations for the supporting system with all relevant data assumed, to the Employer's Representative for his approval. Work shall be carried out on approved drawings only.

8.40 Fire Proof Doors

8.40.1 Material and Workmanship

The design of fire proof doors and the materials to be used in their fabrication have to be such that they shall be capable of providing the effective barrier to the spread of fire. The materials, fabrication and erection of fire proof doors shall confirm to IS: 3614 (Part – I). The fire proof doors shall be obtained from an approved manufacturer. Specific approval for such purchase shall be obtained before hand. Sample approval shall also be obtained from testing authority as per the standard IS: 3614 (Part – 2) for the specified degree of fire rating in hours. All fire proof doors shall have specified sizes and confirm to the description in the respective items of work.

Fire proof door shutters shall be of zinc coated weldable steel (confirming to BS: 6687) or stainless steel (conforming to IS: 304) sheet (18G minimum) fixed in a frame work of rolled channel. The shutter shall consist of an insulating material like mineral wool in required thickness to satisfy the specified fire rating. Normally the thickness of door shutter shall not be less than 35mm for two hour fire rating and 46 mm for four hour fire rating.

The shutter with the required insulating material shall be mounted on angle iron frame or the special made frame from zinc coated (16G minimum) weldable steel sheet. The shutter shall be fixed to frame by means of suitable hinges and shall have a three way latching system. All the doors shall be provided with a coat of primer and one coat of synthetic enamel paint to attain the specified fire rating. All other accessories like hinges, door lock, hold fasts, etc. shall be provided as approved by TAC (Tariff Advisory Committee). All these accessories shall be compatible with the material used for door and shutter.

End of Section

SECTION 9
PIPE BRIDGES

SECTION 9
PIPE BRIDGES

9.1 General

Pipe Bridges shall be proposed over river crossings, stream crossing and crossing of nalla's and storm water drains.

9.2 Earthwork in Excavation

The earthwork shall be in accordance with Section 3. The safety measures to be taken for excavations for open foundations shall be as per guidance laid down in IS 3764.

9.3 Well Foundations

The Construction and sinking of well shall in general follow provisions of IRC 78-1983- Section VII – Foundations and substructure. The latest editions of this code of practice including all applicable official amendments and revision shall be followed. In case of discrepancy between this specification and that referred in code, the specifications will govern.

9.3.1 Setting Out

Necessary reference points shall be fixed, away from the zone of blow-ups or possible settlements resulting from well sinking operations. These reference points shall be connected to the permanent theodolite stations with the base line on the banks. The centre of the individual wells shall be marked with reference to these stations.

9.3.2 Equipment

The following equipments are generally used for the work

(a) Crane with grab buckets - capacity 0.5 to 2.0 cum
(b) Chisels of appropriate sizes
(c) Aqua header for cutting rocky strata
(d) Diving helmets and accessories
(e) Equipment for concrete production, transportation, placing & compaction

9.3.3 Cutting Edge

The mild steel cutting edge shall be made from structural steel section with weight not less than 40 kg/m length and properly anchored into the well curb. The parts of cutting edge shall be erected on level firm ground. Temporary support shall be provided to facilitate erection and maintaining the assembly in true shape. The fabrication may be carried out in the shop or at site. Steel sections shall not be heated and forced into shape. However "V" cuts may be made in the horizontal portion, uniformly throughout the length, to facilitate cold bending. After bending such 'V' cuts should be closed by welding. Joints in the lengths of structural sections, unless otherwise specified shall be fillet welded using single cover plate to ensure the requisite strength of the original section. The cutting edge must be suitably stiffened using plate stiffeners spaced at not more than 1.5m c/c along the periphery of cutting edge. The adequacy of the strength and the efficiency of performance of cutting edge shall be specifically checked by Contractor and necessary alterations made if required at his own responsibility. The weight of stiffeners shall not be considered in weight of cutting edge.

9.3.4 Well Curb

Well curb shall be of cast-in-situ concrete. The outer face of the curb shall be vertical. The bottom ends of vertical bond rods of steining shall be fixed securely to the cutting edge with check nuts or by welds. The form work on outer face of curb may be removed within 24 hrs after concreting. The form

work of inner face shall be removed after 72 hrs. All the concreting in the well curb shall be done in one continuous operation. The curbs should be cast truly in position and if construction of any cofferdam is required, it shall be done by the Contractor at his own cost.

9.4 Well Steining

The dimensions, shape, concrete strength and reinforcements of the well shall strictly conform to those shown in the drawings. The form work shall preferably be of M.S. sheets shaped and stiffened suitably. In case timber forms are used, they shall be lined with plywood or M.S. sheets.

Steining built in the first lift above the well curb shall not be more than 2 meters. For stability, the first lift of steining shall be cast only after sinking the curb partially. Concreting of steining may be carried out in subsequent lifts of about 2 meters. Attempts should be made to minimise the number of construction joints. The construction joints details shall be as shown in drawing and the receiving surfaces of construction joint shall thoroughly be cleaned and prepared using air and water jets before the next lift is poured. The concreting layers shall be limited to about 450 mm restricting the free fall of concrete to not more than 2 m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. As far as possible, construction joints shall not be kept at the location of laps in the vertical steining bars.

The steining of the well shall be built in one straight line from bottom to top such that if the well is tilted, the next lift of steining will be aligned in the direction of the tilt. The work will be checked carefully with the aid of straight edges of lengths approved by the Engineer. Plumb bob or spirit level shall not be used for alignment. After sinking of a stage is complete, damaged portions, if any, of steining at top of the previous stage shall be properly repaired before constructing the next stage.

The height of steining shall be calibrated by making at least 4 gauges (preferably in direction along centre line of bridge and in a direction normal to the centre line of bridge) distributed equally on the outer periphery of the well each in the form of a 100 mm wide strip painted (preferably red colour) on the well, with every half a meter mark shown in black paint (mark thickness shall be 5mm). The gauges shall start with zero at the bottom of the cutting edge. Marking of the gauges shall be done carefully with a steel tape.

After reaching the founding level, the well steining shall be inspected to check for any damage or cracks. The Engineer will direct and the Contractor shall execute the remedial measures before acceptance of the well steining. In case the well cannot be accepted even with any remedial measures, then the well shall stand rejected.

Sinking of well should not be started till the steining has cured for atleast 48hrs. The curing of well shall be continued upto 14 days from the day of concreting. The curing can be by means of water or any approved curing compound.

Any honey combed portion and leakage observed in the steining shall be repaired at Contractor's own cost to the satisfaction of Engineer.

9.4.1 Bottom plug

The concrete mix shall be designed (in dry condition) to attain the concrete strength as mentioned in drawing, and shall contain 10% more cement content than that required for the same mix placed dry, to cater for under water concreting. However, the total cement content shall not be less than 360 kg/cum of concrete with a slump in the range of 150 mm to 200 mm. Admixture may be added to concrete to impart the required strength. The water cement ratio shall not exceed 0.5 and the slump of concrete shall be minimum 150mm. The diameter of tremie pipe shall not be less than 200 mm.

Concrete for the bottom plug shall be laid by Tremie pipe method. Tremie concrete once started shall be continued without interruption for full concreting in the bottom plug. Before commencing

plugging, all loose material from the bottom of the well shall be removed and the inside faces cleaned thoroughly.

Concreting shall be done in one continuous operation till the dredge hole is filled upto the required height and thereafter sounding shall be taken to ensure that the concrete has been laid to the required height.

Least disturbance shall be caused to the water inside the well while laying concrete in the bottom plug and concrete shall not be disturbed in any way for atleast 14 days. To check any rise in the level of bottom plug, soundings should be taken at the close of concreting and once every day for the subsequent 3 days.

The soundness of bottom plug should be tested by de-watering the well by 5 meters below the surrounding water level and checking the rise of water. The rate of rise shall preferably be less than 10 cm per hour. In case rate is higher, remedial measures as directed by Engineer should be taken by contractor at his own cost. The depth of sump below cutting for bottom plugging shall be $1/6^{th}$ the diameter of well. The contractor shall take permission from Engineer before commencing the bottom plug. All necessary inspections like study of strata at founding level, tilt, shift etc. shall be communicated to Engineer before bottom plugging. If any leakage of water is found, then necessary grouting of the plug and the junction of the well to control the same shall be carried out by contractor at no extra cost.

9.4.2 Sand Filling

Sand filling should be commenced after 14 days of laying of bottom plug. The height of bottom plug shall be rectified before starting sand filling. The sand should be clean and free from earth, clay, clods, roots, boulders, shingles etc. and should be backfilled in layers and consolidated by flooding.

9.4.3 Well Cap

The form work for well cap should be prepared conforming to the shape of well cap, concreting should be carried out in dry condition. The bond rods of steining shall be properly anchored into the well cap.

9.5 Sinking of well

Generally, the cutting edge is fabricated and connected to the concrete well curb. On top of the well curb, adequate height of well steining is cast and the process of sinking is carried out. After a portion of the well has been sunk, another height of well steining is cast on top of previous section and further sinking carried out. The process is continued till the bottom level of cutting edge reaches the founding level.

The sinking of the well with use of kentledge shall be commenced only after the steining has been cured for at least 48 hrs. The well should not be placed in a pre-dredged hole. The sinking of the well shall be facilitated by excavating material uniformly from inside the dredge hole. Use of water jetting & divers may be adopted for sinking of well through harder strata with prior approval of the Engineer. The de-watering of well should not be used as a means for sinking of well. Contractor should take necessary precautions to avoid sand blows and he should be prepared at any point of time to tackle the sand blow problem, in case of any occurrence at no extra cost.

In the process of normal sinking any suitable method other than pneumatic sinking as necessary may be adopted. However, no claim due to any confirmations such as boulders, logs of trees met with during sinking or due to any other difficulty experienced in this process shall be entertained. The method to be adopted for sinking of well shall be approved by Engineer. For any change in method of sinking the Contractor shall obtain written permission from the Engineer-in-charge. During the operation of sinking of wells, the strata penetrated through and the behaviour of the well shall be

reported to the Engineer. The decision of the Engineer on any matter pertaining to sinking shall be final and binding on the Contractor.

As the dredging is in progress, soil samples for the study of soil parameters should be collected for every meter depth and the sample should be preserved as per the standard approved practice by the Contractor at no extra cost. The depth of sump in well at any level should not be more than one metre. Further the depth of sinking of well for a particular stage shall be restricted to 1 metre to avoid the sudden sinking of well i.e., jumping of well. A record of depth of dredging from the original bed level should be maintained right from the commencement of sinking of well.

If the well is sunk beyond the founding level specified without prior approval of the Engineer due to any reasons, the Contractor will not be entitled for any extra cost. In case the top of the well project‟s beyond the required level due to unavoidable circumstance, it shall be responsibility of the contractor to dismantle such portion of work at his own cost. However the matter should be discussed with Engineer before any work in this regard is carried out.

9.5.1 Sinking history

The sinking history of well should be maintained in the format given in Appendix 1200/I of "Ministry of Surface Transportation - Roads & Bridges".

9.5.2 Use of kentledge as sinking load

Kentledge shall be placed in an orderly and safe manner on the loading platform and in such a way that it does not interfere with the excavation of the material from inside the dredge hole and also does not in any way damage the steining of the well. When tilts are present or there is a danger of well developing a tilt, the position of the load shall be regulated in such a manner as to provide greater sinking effort on the higher side of well.

9.5.3 Use of Divers

Use of divers may be made both for sinking purpose like removal of obstruction, excavation etc and for inspection. All safety precautions shall be taken as per applicable safety code for sinking withdivers or any statutory regulations in force. Only persons trained for the diving operation shall be employed and shall be certified to be fit for diving by an approved doctor.

The diving and other equipments shall be of acceptable standard and certified to this effect by an approved independent agency. Arrangements for ample supply of low pressure clean cool air shall be ensured through an armoured flexible hose pipe. Stand by compressor plant shall be provided in case of breakdown. All expenses incurred in use of divers, precautionary measures to be taken, casualties etc., will be at the Contractor's risk and own cost.

9.6 Precautions during Sinking

In case wells have to be sunk close to each other and clear distance between them is not greater than the diameter of well; sinking shall be taken up on all wells and they shall be sunk alternatively so that sinking of wells proceeds uniformly. Simultaneous and even dredging shall be carried out in wells in such a manner that the difference in the levels of the sump and cutting edge n the adjacent wells does not exceed half the clear gap between them. Preferably plugging of the wells close to each other can be done together.

Bore chart shall be referred to constantly during sinking for taking adequate care while piercing different types of strata. The type of soil as obtained during the well sinking should be compared with bore chart so as to take prompt decisions.

Before seasonal floods all wells sinking of which is in progress shall be sunk to sufficient depths below the designed scour level. Further they shall be temporarily filled and plugged so that they do not suffer any tilt or shift during the floods. The Contractor can ask for any details related to hydraulics like HFL, LWL, scour depth etc., so as to plan his work suitably. Any losses incurred due to floods etc., by the Contractor due to improper planning of his work will be under Contractor's responsibility. No extra payment will be entertained in this regard.

All necessary precautions shall be taken against any possible damage to the existing foundations, prior to commencement of dredging from inside the well.

The dredged material shall not be allowed to accumulate over the well. It shall be dumped on the downstream and spread as far away as possible. In case the river stream flows along one edge of the well being sunk, the dredged material shall not be dumped on the dry side of the bank, but on the side on which the river current flows.

Very deep sump shall not be made below the well curb, as it entails risk of jumping (sudden sinking) of the well. The depth of sump shall be generally limited to $1/6^{th}$ of the outer diameter or 1m which ever is less.
In case a well sinks suddenly with a jerk, the steining of the well shall be examined to the satisfaction of the engineer to see that no damage has occurred to it.

De-watering shall be avoided if sand blows are expected. Any equipment and men working inside the well shall be brought out of the well as soon as there are any indications of a sand blow.

9.6.1 Tilts and shifts

The tilt of any well shall not exceed 1 (horizontal) in 80 (vertical) and the shift at the well base shall not be more than 150mm in any resultant direction. Tilt's and shifts shall be carefully checked and recorded in the format given in appendix 1200/II of "Ministry of Surface Transportation - Roads & Bridges" regularly during sinking operations. For the purpose of measuring the tilts along the two axes of the bridge, reduced level of the marks painted on the surface of the steining of the well shall be taken. For determination of shift, locations of the ends of the two diameters shall be precisely measured along the two axes, with reference to fixed reference points.

The check for occurrence of tilt should be made every day before the commencement of the work and the readings/ findings should be properly recorded and maintained. The check for shift shall be done for every 1.5m of sinking of well. These recordings shall also be properly maintained.

Whenever any tilt is noticed, adequate preventive measures like placing eccentric kentledge, pulling, strutting, anchoring or dredging unevenly and depositing dredge material unequally, putting obstacles below cutting edge, water jetting etc. shall be adopted before any further sinking. After rectification, the dredging shall be uniform and dredged material shall be spread out uniformly. A pair of wells close to each other i.e., where clear distance between well is not greater than the diameter of well, they have tendency to come closer while sinking. Timber struts may be introduced in between the steining of these wells to prevent tilting.

In the event of a well developing tilt or shift beyond the specified permissible values, the contractor shall have to carry out, at his own cost, suitable remedial measures to the satisfaction of the Engineer, to bring the tilt and shift within the permissible values, as for as practicable.

If the resultant tilt and /or shift of any well exceed the specified permissible values, the well so sunk shall be regarded as not conforming to specification and a sub standard work. Generally it should not exceed 1 in 50 and 300 mm respectively. The Engineer in his sole discretion, may consider accepting such a well, provided the calculations for foundation pressure and steining stresses, accounting for the actual tilt and shift furnished by the contractor show that well is safe. Any remedial measures required to bring the stresses within permissible values (such as increase in the dimension of the well cap,

provision of dummy weights on the well cap) shall be carried out by the contractor without claiming for any extra cost.

In case the Engineer, in his discretion rejects the well, the contractor shall dismantle the rejected well to the extent directed by Engineer and remove the debris. Further the Contractor shall at his own risk and expense complete the bridge with modifications acceptable to the Engineer. The wells which are not conforming to the specified limits of tilts and shifts, if accepted for one or other reasons will be penalised in the form of lump-sum deductions per meter length of well which will be at the discretion of Engineer.

9.6.2 Seating of well

The well shall be uniformly seated at the founding strata. After the well has been evenly seated on good hard rock, arrangements shall be made to facilitate proper inspection in dry and visible conditions before the bottom plug is laid. The founding levels shown in the drawings are purely based on the data available from geo-technical investigations. The Engineer on inspection will decide upon any modifications that may be required to meet the structural aspects. The bottom plugging shall be commenced only after this inspection and concurrence from Engineer.

9.6.3 Tolerances for well steining and well cap

The permissible tolerances are as follow:

(a)	Variation in dimension	:	+ 50mm - 10mm
(b)	Misplacement from specified position	:	15mm
(c)	Surface Irregularities measured with 3m straight edge :		5mm
(d)	Variation of levels at the top	:	± 25mm

9.6.4 Measurement for payment of sinking of well

The depth of sinking shall be measured from the natural bed level to the bottom of the well curb.

9.7 Staging for supporting Form work for super structure

Generally the staging for supporting the form work can be raised from the river bed level. If in a particular span or a bridge, it is found that the erection of staging from the bed level is difficult or not safe due to the adverse soil condition at bed level, i.e., soil being very loose and submerged in water, endangering the stability of staging and form work, the contractor can resort to any other scheme of staging for supporting the form work with prior approval from Engineer. One suggested method is to erect steel framing supported from the pier. No extra cost will be paid for the Contractor for any such alternatives he intends to adopt. The Contractor should study the actual site conditions, anticipate these aspects and quote for the item of work accordingly. Contractor should take prior approval from the Engineer for any such scheme before commencing the execution of work. The contractor will be deemed to be aware of the fact that these rivers are subject to flash floods and he should plan his works to avoid such adverse conditions.

9.8 Elastomeric Bearings

The design, construction, installation and maintenance of the bearing shall in general follow provision of IRC 83 part II - 1987.

The bearings provided are laminated bearings 160mm x 320 mm in plan with a total thickness of 33 mm. Outer layers of elastomer are 4 mm in thickness and two internal layers are of 8 mm thickness, laminate used are 3 nos. 3 mm thick stainless steel conforming to SS 316 L.

Bearing with steel laminates shall be cast as a single unit in a mould and vulcanised under heat and pressure. The moulds used shall have standard surface finish adequate to produce bearings free from any surface blemish. Stainless Steel laminates shall be clear of all mill scales and shall be free from all contaminants prior to bonding. Rusted plates with fittings shall not be used. All edges of plates shall be rounded. The fabrication of bearings shall conform to IRC 83 (Part II).

Inspection and acceptance criteria shall be as per IRC 83.

Care shall be taken in packing, transportation, storage and handling to avoid any mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather. Bearing shall be placed between true horizontal surfaces and at true plan position of their control lines marked on receiving surface (Maximum tolerance ± 3mm. Concrete surface shall be free from local irregularities (maximum tolerance ±1 mm is height).

Bearing shall be fixed to the abutment or pier as the case may be, by applying epoxy based adhesive to the interface, after surface preparation as specified by the manufacturer of the bonding agent. The bearing shall be placed in a recess as a measure of safety against accidental displacement.

For cast-in-place concrete construction of superstructure, where bearings are installed prior to deck concreting, the forms around the bearings shall be soft enough for easy removal. Forms shall also fit snugly and prevent any leakage of mortar grout. Any mortar contaminating the bearings during concreting shall be completely removed before setting.

End of Section 9